WAR SURGERY OF THE ABDOMEN

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TO

THE STRETCHER-BEARER

PREFACE

This Book contains the experiences in abdominal surgery of a sector of the battle line over a period of thirty months. It is founded on the practice of many surgeons, working under different conditions and in different hospitals. The personal equation and influence of locality have thus been largely eliminated. It is hoped, therefore, that the figures quoted may present a standard with which other surgeons can compare their results.

My thanks are due to the Medical Research Committee for the great help it has given. It has provided the means of recording and tracing the cases. The illustrations are the work of its artist, A. K. Maxwell, to whom I would also express my indebtedness. Many of the blocks have been kindly lent by the Medical Society of London and by the *British Journal of Surgery*.

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Cuthbert Wallace.

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WAR SURGERY OF THE ABDOMEN.

CHAPTER I.

INTRODUCTORY.

Foreword.

It may be asked if there is really such a thing as war surgery as distinct from civil surgery. Fundamentally there is not so much difference as might be thought. What difference there is lies in the anatomical nature of the injuries, such injuries being influenced in a certain proportion of the cases by the high speed of the projectile and by the carrying into the wound of infective material.

It is a question as to whether war conditions allow the surgeon to apply the principles that he knows to be right. No man shot in the belly would be left to lie in bed in the civil hospital of a great town. The expectant treatment was only adopted because the surgeon could not operate under favourable conditions.

War surgery is largely concerned in overcoming adverse circumstances and in striving to make war conditions as much like peace conditions as possible. It is in great measure a matter of when and where to operate and how best to move the wounded man to the place where he will win back to health.

At first the circumstances of the surgeon are strange. He cannot at first orient himself or get his bearings. Strange problems present themselves, and the surgeon feels lost. As he grows more familiar with his surroundings he recognises that his enemies are the same, but under a new guise. Then his way becomes clearer, and he perceives that the old surgical truths are as true as ever.

Take compound fractures. Early on in the war these were practically untreated as regards attention to the interior of the wound until they arrived at the base many hours after their receipt. They did badly, and what surgeon in civil practice would be surprised if fractures left uncleaned for sixteen to twenty-four hours exhibited violent sepsis? When preparations were made at the Front for mechanical cleaning within a few hours of the wound—when the civil practice gained acceptance—there was at once a vast improvement. It took nearly three years of war to evolve this method, and yet it is in the books written years ago.

Again, take the battle of antiseptics as applied to recent wounds. It was a failure of antiseptics, and not of asepsis, if there was a failure. Surgeons, horrified at the bad course of the wounds, tried antiseptic after antiseptic. This trial was bred of despair, and as in the past, so in this war, we have seen the surgeon turn from one chemical to another. It was not until the well-established surgical practice of excision of dead and dirty tissue was again adopted within a reasonable time of wounding that any material progress was made.

All surgery must be governed by the conditions in which it is practised and must, therefore, be somewhat modified by war, but in no previous war has the medical man had it so much his own way.

Most of the doctors in this war were till lately civilians, and possibly inclined to be impatient of routine. Without administration or routine the finest hospital would be of but little value, for patients would arrive late and in bad condition; on the other hand, administration largely exists to allow the doctor to practise his art.

Utility of Former Experience.

This is somewhat doubtful. In some ways it has been a hindrance. In judging the number of wounded, the proportion of killed to wounded, the accommodation required, it seems to have been a help, for such things alter but little, though

they are altering. As a general guide to surgery it has, if anything, been somewhat of a handicap.

In South Africa one learnt to treat many wounds with little respect. Wounds were allowed to scab over, and did remarkably well. Many surgeons became convinced that rest, starvation, and morphia were the right treatment of abdominal wounds. This war, fought on an infected soil, has proved that dirty wounds must be cleaned. It has also shown that the penetrating abdominal wound should be explored.

Exchange of Knowledge.

The changing conditions of wars seem to show that surgical histories brought out after the war are largely a labour loss, if not a waste of time. A series of well-observed cases and the careful drawing of deductions while the war is in progress are worth pages of statistics when the fight is over. Every effort must be made to summarise and render accessible the experiences of the early months for use in the later. This has been done by both combatant and medical branches by means of pamphlets, instructions, lectures, and demonstrations.

The Army is full of schools, where officers and men are taught new methods. A short course at a school is more valuable than sheets of printing, and produces greater results.

The passing of a wounded man from one unit to another is unavoidable in war, but every means must be taken to lessen the disadvantage. This is best done by sending careful notes with the patient as he passes from the Front to the Base and by letting the surgeon, who first had charge of the case, know his after-history. The front line surgeon can thus collect data and modify his treatment accordingly. It should be just as incumbent on the Base to supply information to the Front as for the Front to supply the Base.

Sympathy between units is very necessary for the smooth and efficient working of the medical service. There is always a tendency to criticise the unit in front of you ; but it is well, if you feel thus inclined, to try and put yourself in the place of the man from whom you received the case. An exchange

of information leads to good feeling. A friendly criticism is helpful, a captious criticism distinctly harmful.

Again, one of the most useful functions of a consulting surgeon has been the carrying of facts and opinion from one unit to another. The so-called radial method of surgical control is best, that is, where the surgeon is responsible for the wounded of a certain sector of the line both at the Front and Base. Unfortunately, this cannot be always managed, and in heavy fighting the wounded from one portion of the line will flow into many base areas. In quiet times it is possible under certain conditions, and much knowledge is thus gained that can be utilised in fighting times. It is the peace-time observation that is so useful, as then there is time for deliberate thought.

Medical societies have been instituted in different areas, and have done good work. One society where medical officers both from the Front and Base, have met, has been of the greatest value. Men who meet and discuss matters will seldom quarrel, especially if they dine together afterwards.

Surgical Opinion when the War started.

There is no doubt that for many years it has been held that the operative treatment of abdominal wounds was not to be advised under war conditions. This was partly due to want of success, and partly to the fact that many military surgeons were opposed to extensive operating anywhere near the firing line. As abdominal surgery, to be successful, must be done at once, it is obvious that it could not be undertaken with success where all operations had to be postponed to a late period. Although the expectant treatment was the orthodox one when the South African War broke out, many civil surgeons hoped to prove that it was wrong. Surgeon-General W. F. Stevenson even issued an appeal for the trial of operation. The result was, however, only to confirm former opinion, though this opinion was now held on two somewhat different grounds. One school held that the expectant treatment was in itself the right procedure, the other that it was the best that could be done in war.

Some people believed that wounded intestine healed suffi-

ciently often to warrant abstention; others, headed by Makins, believed that small-gut lesions were practically always fatal, and that the success obtained by the " wait and see " policy was due to the escape of the bowel, although the belly had been penetrated. Makins' opinion that the small gut area could be traversed by the small bullet without injury has been proved in this war. If one reads the literature of the South African War, both private and official, the reason for want of success is at once obvious—the cases arrived too late. It was not so much a question of the success of the expectant treatment as a failure of the operative. Operations were secondary or late, and two strikingly successful cases of resection of small gut (Messrs. Neale and Tuke) were operated on within six and twelve hours respectively.

The reason for the late operation was the nature of fighting in an unsettled country of great distances. The wounded could not be quickly brought to a hospital equipped with the necessary appliances. To operate in the veldt with what appliances were at hand was too disheartening. It was impossible to get even moderately decent conditions. There was little or no water, and what there was was often too filthy for words—the water of dams. In addition there was the plague of flies and dust that settled on everything. Lastly, the operated man could not be kept quiet; it was lucky if he could ride in a horse ambulance.

The conditions were utterly different from what now pertain, and this is the first time since the rise of abdominal surgery that a great campaign has been fought in a settled country, and, what is more important still, with a fixed fighting line.

The small number of figures dealt with in the South African campaign was also a source of error. In order to form an adequate idea of the efficacy of any treatment it is necessary to strike an average over a large series of cases. Now, in this present war, one of the difficulties of establishing the operative treatment was the runs of bad luck which any operator had to face. Even now, with conditions as near ideal as possible, one may meet a series of nine consecutive fatal cases. This must have a very depressing effect on any young surgeon, or one who

is not convinced that the operative treatment is, in the main, the best of all. Now, nine abdominal cases mean, roughly, about 600 wounded men, taking a moderate estimate of the proportion of abdominal wounds to total wounds. As a matter of fact, in the South African campaign, a casualty list of 600 wounded was considered a large one. It can therefore be seen that if an operator happened to encounter such a series it is not a matter for surprise if he had doubts as to the correctness of his procedure.

The statistics of the South African campaign are very defective. Surgeon-General Stevenson, in the official history of the war, was only able to collect 207 cases of abdominal wounds. Among them it is stated that there were 26 laparotomies with 18 deaths, a mortality of 69·2 per cent., and according to Stevenson the mortality was really even worse. The total death-rate of all abdominal wounds quoted, operated and unoperated, is given as 30·4 per cent.

In his most recent work (1910), " Wounds in War," the mortality is shown as 51·6 for laparotomies, the total cases remaining the same—namely, 207. In any case the numbers are really too small to have any real value.

Figures show that in the present campaign a mortality of 50 per cent. is a good result, but such a mortality in civil practice would be considered an awful death-rate to face. And yet it means, looking on the bright side, many lives saved.

There is no doubt that certain people shot through the abdomen in South Africa, and treated expectantly, recovered. As a matter of fact, there were two officers well known in the Royal Army Medical Corps who recovered after such treatment, and I have no doubt that a knowledge of their recovery greatly strengthened the opinion that expectant treatment was, on the whole, the best.

The South African campaign may then be said to have left surgical opinion opposed to operation. This opinion seems to have been only strengthened by succeeding wars—the French War in Morocco, the Balkan War, and the Russo-Japanese War.

Method of Treatment in the Earlier Period of the War.

It is not intended here to say anything about the period of the retreat. Under such conditions adequate provision for operating near the Front was an impossibility, and all that could be done was to get rid of the wounded to the Base with the least possible discomfort to them. When the line became fixed the conditions were very different, and there was a possibility of operating under good conditions. It was no longer a question of whether a man could be operated upon, but whether he should be operated upon. Still, however, the old belief in the efficacy of the expectant treatment obtained.

In order to understand what was done during this period it is necessary to say a word or two about the standard system by which the wounded man was evacuated. Shortly, it was as follows : A wounded man was first seen by the regimental medical officer, to whom he was brought in the regimental aid-post situated somewhere in the trench system. He was then transferred by a stretcher to an advanced dressing station, usually situated just behind the trenches, and from there by car to the Field Ambulance, and there he was kept until the time the motor convoy arrived, often only once in the twenty-four hours. By this he was taken to the Casualty Clearing Station, which was the first place adequately equipped for operative treatment. In the early days the Clearing Station was a very different hospital from what it is now, but still there was reasonable facility for the performance of any operation if it was thought advisable. With the idea of avoiding the disturbance of movement, a man wounded in the abdomen was kept sometimes, though not usually, in the regimental aid-post ; often he was kept at a Field Ambulance, but usually he was transferred to the Casualty Clearing Station and there treated.

The usual mode of procedure was to put the man in the Fowler position, to improve the general condition by rest and warmth, to withhold food and water for three days, and to administer morphia. The thirst, which was a distressing symptom of this treatment, was combated to a certain degree by rectal salines and mouth-washes.

I should like here to pay tribute to the great care and attention which the medical officers lavished on the cases. Certain officers were told off day and night to attend to these patients, and everything that could be done to alleviate their suffering and to make them as comfortable as possible and to cheer them up was done. If anything could have got these men well the attention that they received would have done so. The people who conducted the treatment were firmly convinced of its efficacy.

This belief was strengthened by the behaviour of the patient. Many patients, at first gravely ill, went through a period of improvement which often was very striking. It was in a way unfortunate, but there is no doubt that improvement did take place, and so well were many of them that they were evacuated to the Base, and arrived there sometimes in good condition and sometimes gravely ill. The men who saw the cases leave them apparently on the way to recovery could not bring themselves to believe that such cases did badly at the Base. It was unfortunate that the means of communication between the Base and the Front was, in those days, inadequate, and this serves to emphasise what has already been stated about the value of free interchange of reports between the Front and the Base.

If evacuation of these cases had not been necessary and it had been possible to keep them at the Clearing Stations, the expectant treatment would not have survived as long as it did, for medical officers would have seen such cases become worse and worse, and in the end die. As a matter of fact, during my six months' experience at the Red Cross Hospital at Netley I only saw two cases of wounds of the abdominal viscera ; one was a case of cæcostomy and the other a transverse colostomy.

The expectant treatment was also a very trying time for the wounded man. The knowledge that nothing could be done for him by operation, and that the only thing was to wait events, had a very depressing effect on the soldiers, although the medical officers did everything to cheer them up.

It is curious, but true, that the wounded soldier welcomes operation. He feels that something is being done for him. I

have sometimes been asked the question, " Can't you operate ? "
If I have answered in the negative, with an assurance that
operation was unnecessary and that he would do well, I have
often detected a look of disappointment on the patient's face.
Operation has no horror for the soldier.

Experiences of the Allies.

The French have gone through the same experience in the
treatment of abdominal wounds.

I cannot do better than quote you a letter which Professor
Tuffier has kindly written me. He says :—

" Abdominal surgery has undergone in France the following
revolution. Until the month of February, 1915, installations
did not allow one to operate, under good conditions, on wounds
of the abdominal cavity, and abstention was necessary in these
circumstances. At this period I found in a small ambulance
quite near the Front, and very well organised, several cases of
cure of wounds of the intestine by laparotomy. I reported them
to the Society of Surgery, and a movement commenced in
favour of operation for all abdominal wounds. It is because the
motor surgical ambulances and the medical arrangements have
been better organised, and because the evacuation of the
wounded has been done in a relatively short time, that we have
been able to arrive at a certain measure of success."

With the French, as with us, the period of the retreat corre-
sponded to the period of expectant treatment, and when the
line became fixed the treatment underwent the same change
as it did in the British Army. As a matter of fact, after the
establishment of the operative treatment some French surgeons
have from time to time again championed the expectant treat-
ment, but this finds little acceptance with the majority.

Commencement of the Operative Treatment.

Although rest treatment was the rule in the first days of
the war, some attempts at operation were made. Souttar also
commenced early operation with the Belgian Army. Owen
Richards was the first, I believe, to publish results of operative

treatment in the British Army.*   His first operation was per-
formed on January 28th, 1915, and the first successful case,
that of a resection of $2\frac{1}{2}$ feet of the small intestine, was
operated upon on March 18th, 1915, thirty-six hours after receipt
of the injury.   A few other British surgeons had tried what
could be done by operation, but the results were undeniably
bad, so bad that most people had abandoned the attempt.
The reason for this was, no doubt, the late arrival of the cases
at a place where an operation could be performed.

In June, 1915, a series of operations and *post-mortem* examina-
tions showed that the injuries were of such a nature that
recovery was not to be expected without surgical aid except in
a few instances.

It was also found that hæmorrhage was a frequent cause of
early death, and that bullets produced very extensive injuries.
It has always been granted that hæmorrhage was the chief cause
of early death, but the advocates of expectant treatment seem
to have focussed their attention more on the danger of peri-
toneal infection and the possibility of its localisation or dis-
appearance than on the possibility of spontaneous arrest of
hæmorrhage.

The discovery that bullets produced extensive gut injuries
was also of great importance, as much stress had been laid on
the smallness of the lesions produced by the modern small-bore
bullet ; in fact, the hope of spontaneous recovery from gut
lesions was based on the assumption that such projectiles were
comparatively innocuous.   This idea was constantly put forward
in the early period of the war.

The re-establishment of the fact that hæmorrhage was the chief
cause of early death was of great importance, as it showed that
only by rapid evacuation could one hope to combat such a con-
dition.   In June, 1915, Surgeon-General W. G. Macpherson
directed some of the Field Ambulances to send the abdominal
wounds with all possible celerity to the nearest Casualty Clearing
Station.   The results obtained by this small experiment were
encouraging, and in the first week in August, 1915, an order
was given which made the rapid evacuation of abdominal

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* *Brit. Med. Journ.*, August 7th, 1915.

wounds the official method. This was followed by rapid improvement in the results obtained.

Collection and Evacuation of Wounded.

In forming a judgment on the results obtained by the operative treatment of abdominal injuries and where it is best to operate on them it is necessary to know something about the means by which such cases reach a Casualty Clearing Station. A knowledge of the difficulties is also necessary in order to form an appreciation of the really magnificent work which is being done by the regimental medical officer and his stretcher-bearers, and by the *personnel* of the Field Ambulances. One can consider this subject under two heads : (1) the collection ; (2) the evacuation of the wounded man.

(1) By *collection* is meant the finding and bringing back to the Regimental Aid-Post of the wounded ; and without going into particulars it can be well understood what the difficulties are when an attack has been made and our troops have advanced. If it is difficult to find and collect the wounded after a successful attack, it is still more difficult when the fortunes of battle sway backwards and forwards ; and it is under the latter conditions that the wounded lie out for a considerable period. In quiet times the collection is not difficult, for the men are wounded very often in the trenches themselves.

(2) *The Evacuation.*—A man has been wounded in the front trench. The first field dressing most probably will be applied by himself or by one of his companions, possibly by the medical officer himself. The patient will then walk, be carried, or be taken on some kind of stretcher to the Regimental Aid-Post. Even this is performed under considerable difficulties, because the nature of the trench system involves getting round many sharp angles. The Regimental Aid-Post is situated somewhere in the trench system or in a communication trench. To reach this, even in quiet times, an hour or more may sometimes be required. It is in a dug-out, a cellar, or a ground floor room reinforced and sandbagged. There is a dressing-room, fitted up as well as possible with shelves and trestles. Adjoining will be some place

where the wounded may rest till evacuated. There may be electric light, though usually there is only an acetylene lamp or a humble candle. It is not a place where any one would wish to perform a capital operation. Here the patient will be attended by the regimental medical officer. He will be properly dressed, fed, given hot drinks, warmed up, adequately covered with blankets, and provided with hot bottles.

Under the present system of evacuation an abdominally wounded man will not wait in this place. Now commences the long journey—sometimes as much as two miles—down the communication trench. Sometimes the journey is so arduous that one complete tour is all that a stretcher party can manage without a long spell of rest. Underfoot are the duck boards or a rough brick pavement. The provision of these renders walking more easy, but the surface is necessarily uneven, especially where one board joins another. Sometimes a rung is out, and at other times the board is apt to tilt and look you in the face. Then there are the innumerable corners formed by the zigzags of the trench made to stop the enfilade fire and limit the danger of an exploding shell, or to prevent the enemy looking straight down the trench.

In summer the air is stifling. In winter, or after rain, the surface of the boards is greasy in the extreme, and sometimes they are completely under water. At night-time the difficulties, as may be well imagined, are greatly increased. Sometimes the turns in the trenches are so sharp that the traverses of the stretcher have to be closed in order to allow its passage round the corners, or it has to be lifted high above the angle.

Much ingenuity has been expended in devising stretchers for the easier transit of the wounded man, for getting round corners easily, and relieving the work of the bearers. In most cases the stretchers are carried on the bearers' shoulders ; the regulation method has been found much too fatiguing.

Many wheeled stretchers have been tried, but the inequalities of the ground and the sharp corners to be turned are difficulties which have not yet been overcome. Sometimes it is possible to put a man on a trolley-line or light railway and run him down over the open ground. In some cases the trenches have

an overhead mono-rail on which a short form of stretcher can be suspended.

At the end of the communication trench the patient comes to the Advanced Dressing Station. This, as a rule, is more spacious than the Regimental Aid-Post, but similar in construction. Here the patient is again warmed up and given drink. The hot bottles are changed or refilled and the patient despatched, if his condition warrants it, in a motor ambulance to the Casualty Clearing Station or Advanced Operating Centre. Sometimes the ambulance will call at the Field Ambulance if this is not off the route.

The above description applies to comparatively quiet times. In times of battle there may be no dug-outs, cellars, or overhead shelters. The wounded man must be attended to in the open, in the lee of a wall or " pill-box," and then to reach the Advanced Dressing Station he must be carried 3,000— 5,000 yards across the open, the bearers on whose shoulders the stretcher rests picking a precarious way along the edge of innumerable shell-holes filled with mud and water.

Selection of Cases for Rapid Evacuation.

The rapid evacuation of all abdominal cases to the Casualty Clearing Stations puts a great deal of responsibility on the Field Ambulance officers. It is no light task to decide what cases can stand evacuation ; in fact, it is one of the most difficult things that a medical officer is called upon to determine. . Many patients, of course, are better for rest and food and warmth ; but in the case of abdominal wounds it must be remembered that hæmorrhage is the chief cause of early death, and that the only hope for their salvation lies in the arrest of the hæmorrhage by surgical means. It is therefore obvious that it is worth while taking risks in cases of abdominal wounds which it would not be right to take in other cases. There is also the danger of death from peritoneal infection, but experience has shown that the need for celerity on this account is as nothing compared to that necessary on account of hæmorrhage.

CHAPTER II.

A General Review of Abdominal Wounds.

Relative Frequency of Abdominal Wounds.

In the earlier period of the war there was some difficulty in arriving at an accurate figure. There was the difficulty of diagnosis in the first place. In the second place, it was found that the data varied according to the persuasion of the surgeon who made the observations. A medical officer who believed in the expectant treatment gave a higher proportion than one who favoured operation. Again, the Field Ambulances always gave a higher number than the Casualty Clearing Stations.

The difference between the figures in the Field Ambulances and Casualty Clearing Stations is accounted for in the following manner : (1) the Field Ambulance would naturally and rightly err on the side of making the graver diagnosis ; (2) the mortality was high in the Field Ambulances, so that fewer cases reached the Casualty Clearing Station ; (3) at the Casualty Clearing Station a more careful diagnosis acted in two ways : (a) it included some buttock, chest, back, and thigh wounds as abdominal wounds ; (b) it excluded many cases of wounds of parietes. On the whole the effect was to lessen the proportion of abdominal wounds to total wounds.

With the establishment of the operative treatment and the keeping of accurate records the errors have diminished. It is now possible to state that the number of abdominal wounds that reach an operating hospital is not likely to exceed 2 per cent. of the total wounded received, provided that no segregation of such cases is practised.

Nature of the Projectiles that cause the Wounds.

Bullets.—There are very many different kinds of bullets used in this war, and apparently their number goes on increasing.

As is well known, the standard English, French, and German bullet is a pointed one. The English and German is a composite projectile which is liable to break up into mantle and core. The French bullet is much longer than either of the above, and is made of solid copper alloy. Although not liable to break up, it is liable to very great distortion. Naturally we are mostly concerned with the German projectile, which, as a rule, is pointed, but sometimes the old ogival-headed bullet has been extracted from wounds. All the modern pointed bullets are more unstable than the bullets of the Boer War. The instability is said to be most marked at the beginning and the end of the flight. In this war, where the fight takes place amongst houses, there are many opportunities for the bullet to be deformed and deflected. Again, the velocity and stability of a bullet is largely affected by passing through sandbags or a parapet, which, as a matter of fact, has to be something like 4 feet thick to be bullet-proof. There is plenty of evidence that, whether from inherent instability or from hitting some object, the bullet does spin, and in several cases a bruised impress has been seen on the skin which could only have been made by a sidelong impact of the bullet. Again, in those cases where two legs have been wounded by the same bullet the first leg has been perforated by a small standard track, and the opposite leg has suffered a large gaping wound, the obvious explanation being that the bullet in passing through the first limb was made to spin, and so caused a more extensive wound on the opposite member. A good deal has been heard about the explosive effect of the modern pointed bullet ; and although one may say that it does cause worse wounds than the ogival-headed projectile, I am by no means persuaded that its so-called explosive effect is anything but a very rare occurrence. I am strengthened in this opinion by the study of accidental wounds, of which one sees a great number. Men are shot at all sorts of close ranges up to actual contact, and yet, unless a hard bone is touched, it is not usual to get the explosive type of wound.

Shell Fragments.—These are, of course, of all sizes, but the fragments which are the cause of the abdominal wounds that the surgeon is called to treat are generally not more than 1½ inch

Fig. 1.—Types of Projectiles that cause Abdominal Wounds.

(1) Piece of H.E. shell. Wounded small gut and lodged in mesentery. (2) Rifle grenade fragment. Penetrated through the gastro-hepatic omentum and divided all the tissues of the left kidney. (3) German bullet. (4) British bullet. (5) Shoe nails from an early German bomb. (6) Fragment of grenade. Wounded small gut. (7) Lead fragment. Penetrated the back and wounded jejunum. (8) Fragment of H.E. shell. Penetrated buttock and wounded bladder. (9) Fragment of bomb. Penetrated the back and wounded jejunum. (10) Bomb fragment. Penetrated under ribs and wounded kidney. (11) Shell fragment. Wounded jejunum in three places. (12) Fragment of H.E. shell. Penetrated belly wall, carried in portions of clothes, but wounded no viscus. (13) Fragment of H.E. shell. Wounded liver, small gut, and pelvic colon. Drawn natural size. (*Medical Society* and *Brit. Journ. of Surgery*.)

in the greatest diameter, usually a good deal smaller. There are different kinds of shells used, and some importance may be attached to the nature of the shell by which the man is wounded.

High-Explosive Shells.—These shells may burst in the air, on contact with the ground, or after they have impacted themselves deeply in the earth. The velocity of the fragments into which the shell is blown depends both on the " remaining velocity " and on the disruptive charge, and the fragments fly out mostly in a forward and lateral direction. The shape of the fragments depends largely on the type of shell—if the shell is segmented, the pieces are more or less quadrilateral ; if not segmented, the fragments are still more or less quadrilateral in shape, and have extremely sharp and ragged edges. Such shells, bursting on the ground, naturally become covered with dirt.

The knowledge of where a shell bursts in relation to the patient is sometimes of importance as telling whether the abdomen is involved. If a shell bursts above a man who is wounded in the lower thorax it is likely that the fragment has entered the peritoneum. Again, if a man is hit in the buttock and the shell explodes on the ground the possibility of the pelvis being involved should at once be borne in mind. An officer was riding along a road, and a shell burst on percussion quite close to him. He had a buttock wound. A fragment was found to have entered the pelvis and torn the small gut and a large pelvic vein.

Shrapnel.—These shells usually burst in the air with a time fuse. They are of all sizes, and the metal balls with which they are filled also vary somewhat in size. The penetrating power of such balls is due to the remaining velocity of the shell. The direction of the shrapnel balls will, as a rule, be downwards. In some cases a shell is of a combined high-explosive and shrapnel type.

Shell Caps.—These come from both types of shell and form some of the largest fragments that the surgeon meets with. They often cause contusions without perforation.

Bombs and Grenades.—In the early part of the war these bombs were often extemporised, and consisted of tin boxes

filled with an explosive, scrap iron, cobblers' nails, and screws, etc. Nowadays they are made of iron, the surface of which is marked with grooves, so that on explosion they break up into quadrilateral fragments. Sometimes the force of the explosive will cause a bomb to burst into smaller fragments, often no bigger than a big match-head. Although small, these fragments have—apparently from their high velocity—a very great penetrating power in the immediate neighbourhood of the explosion, though this is rapidly lost as the distance increases.

Trench Mortars.—Bombs from these are of various shapes, but consist essentially of a very large high-explosive charge with a comparatively thin containing envelope ; they therefore very often burst into large ragged fragments as well as minute ones. They are generally timed to burst either on the ground or in the ground.

Bayonet Wounds.—These are very seldom met with, being usually fatal on the field. Mention may be made of two cases. In the first the bayonet penetrated the man's back and came out by his umbilicus ; no viscus was injured, and the man succumbed to hæmorrhage. The second was the case of a man who was late in answering a challenge, and was bayoneted by the sentry ; the bayonet entered the left hypochondrium, wounded the greater curvature of the stomach, and entered the back wall of the abdomen ; though promptly operated on, he died, not of his stomach wound, but of retroperitoneal sepsis.

Relative Number of Different Projectiles and the Proportion retained.

Table I. has been drawn up with the intention of giving some idea of the relative frequency of the different projectiles met with in abdominal wounds ; it also shows the number retained in the body. This table must be taken as only approximately correct, for several reasons. In the first place, it is often impossible for a man to tell what hit him ; in the second place, one cannot always be sure, from a study of the entrance and exit wounds, what was the nature of the projectile ; and, again, many do not differentiate between high-explosive shell and shrapnel, the soldier generally including most shells which are

not of a large calibre under the name of shrapnel. As a matter
of fact, there is very little difference in the nature of the frag-
ments in high-explosive shells, bombs, rifle grenades, or trench
mortars, if one excludes the larger fragments, with which we
are very little concerned.

TABLE I.—*Relative Frequency of Different Projectiles met with
and of those retained. Total Number of Cases*, 834.

—	Bullet.	Shell Fragment.	Shrapnel.	Bomb or Grenade.
Out	203	30	15	6
Retained	131	254	67	128
Total ..	334	284	82	134

Bullets.—Bullets and high-explosive shell furnish the larger
proportion of abdominal wounds. More bullets pass through
the body than other projectiles ; the reason for this is obvious.
The causes for retention are not so obvious, and I have known
bullets, fired at a comparatively short distance, remain within
the body. In other cases the bullet may have passed through
the earth, and so have had its velocity diminished. Ricochets
account for a certain number.

Shells.—These show a high proportion of retention, which is
obviously due to the shape of the fragments.

Bombs and Grenades.—The retained fragments are strikingly
in excess of those passed out.

The large proportion of retained fragments at once suggests
the possibility of armour ; and no doubt armour could be
devised which would keep out many fragments. It really is
more or less a question of what the soldier is able to carry. One
cannot help being struck with the resistive power of an ordinary
book, as one has often seen projectiles arrested by such articles
when carried by the soldier. The great saving of life effected
by the steel helmet makes one hope that something may be
produced equally efficacious in protecting the body. Although

we could not expect such shields to be supportable and at the same time bullet-proof, yet many bullets have lost so much velocity that they are retained, and the number of bullets is greatly outnumbered by shell and bomb fragments, which possess far less penetrative power.

Relative Mortality of the Different Projectiles.

The following table shows that bullets are but little less dangerous than shells, and that bombs and grenades are the least noxious :—

TABLE II.—*Relative Mortality in 629 Cases.*

—	Bullet.	Shell Fragment.	Shrapnel.	Bomb or Grenade.
To Base	91	105	15	60
Died	106	154	40	58
Total . .	197	259	55	118

General Incidence of Wounds.

The charts (Figs. 2 and 3) were made by plotting the entrance wounds on the front and back of the body respectively. The wounds of the back form a substantial proportion of the whole. There is a tendency for the wounds to collect towards the sides, especially on the back of the body.

The comparative absence of mid-line wounds is also seen in Fig. 3, which represents the wounds in cases too bad for operation when they reach a Casualty Clearing Station. This distribution is brought about by the presence in the mid-line of the spine and the great vessels. Men shot in these situations die on the field of battle. The collection of wounds towards the sides of the body may possibly also be caused by the fact that a man's front and back are more or less protected in the trench, while the sides of the body are open to enfilade fire. Many of the wounds on the back, especially those of the buttock and thigh,

are due to bombs and rifle grenades. The posterior wounds show a larger proportion of deaths than the anterior.

Influence of the Position of Wound and Direction of Missile on Prognosis.

CASES TOO SERIOUS FOR OPERATION.—The chart (Fig. 4 was obtained by plotting the entrance wounds and the track of the
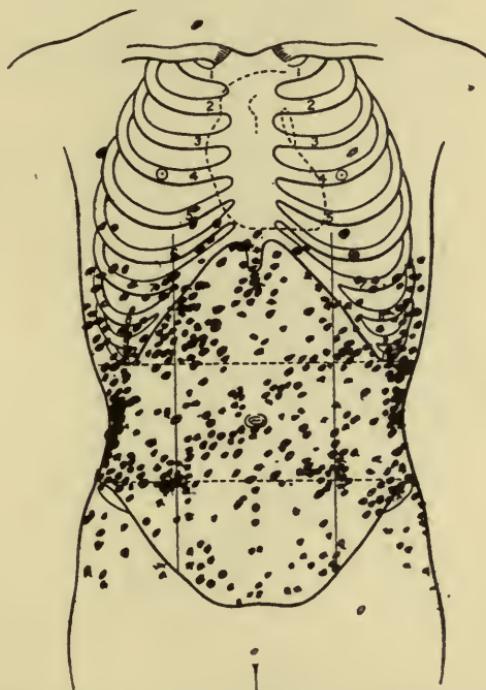

FIG 2.—Regional incidence of wounds. Front view. 429 wounds. Mortality 53 per cent.

bullet, when known, in those cases which arrived at the Casualty Clearing Station in such a condition as to preclude any operative procedure ; they all died. It is rather striking to notice how the chart becomes blackened in a fan-shaped area, the apex of which is the left hypochondrium. There is a comparative absence of mid-line wounds and of hypogastric wounds. This must not be taken as meaning that hypogastric wounds are not dangerous, but only that they do not cause such injuries as to render operation useless. The side-to-side wound would appear to be

the most dangerous among wounds that reach an operating unit. This seriousness was noticed in the South African campaign.

In the chart (Fig. 3) are a good many buttock wounds. From experience gained in operating on such cases, we must regard lesions of the pelvic vessels as a fairly frequent cause of death.

The mortality that accompanies abdomino-thoracic injuries
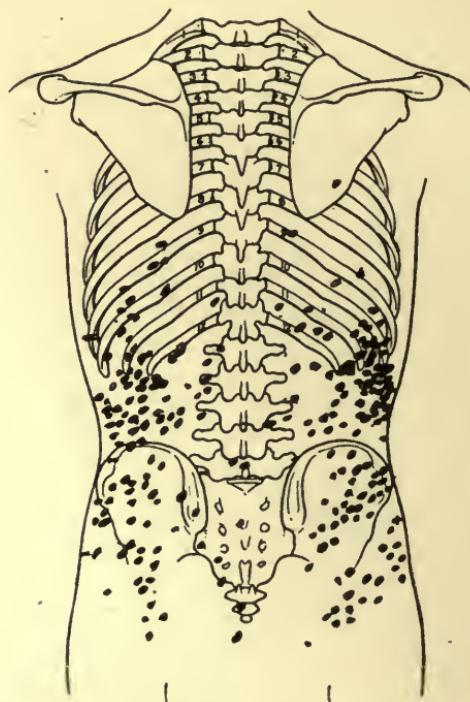
FIG. 3.—Regional incidence of wounds.   Back view.   222 wounds.   Mortality 60 per cent.

is possibly explained in part by the fact that such wounds involve this dangerous hypochondriac area.

Some curious instances of side-to-side wounds may be of interest : (1) A wound of the upper pole of the left kidney and lower pole of the right, wound of ascending colon; paraplegia ; fatal.   (2) Wound of the right kidney and spleen, vertebra penetrated; no paraplegia ; fatal from splenic hæmorrhage. (3) Spleen torn on its anterior edge, left kidney perforated through its centre, upper pole of right kidney destroyed ; fatal (bullet).   (4) Wound of the left kidney and the posterior surface

of the ascending colon ; fatal. (5) Hepatic and splenic flexures alone wounded ; fatal.

In sixty-eight cases a *post-mortem* was performed ; Table III. shows the injuries, and Table IV. the number of times individual organs were hit.

In nearly every case there was much blood in the abdomen, and in thirteen cases the note is made that death was due to
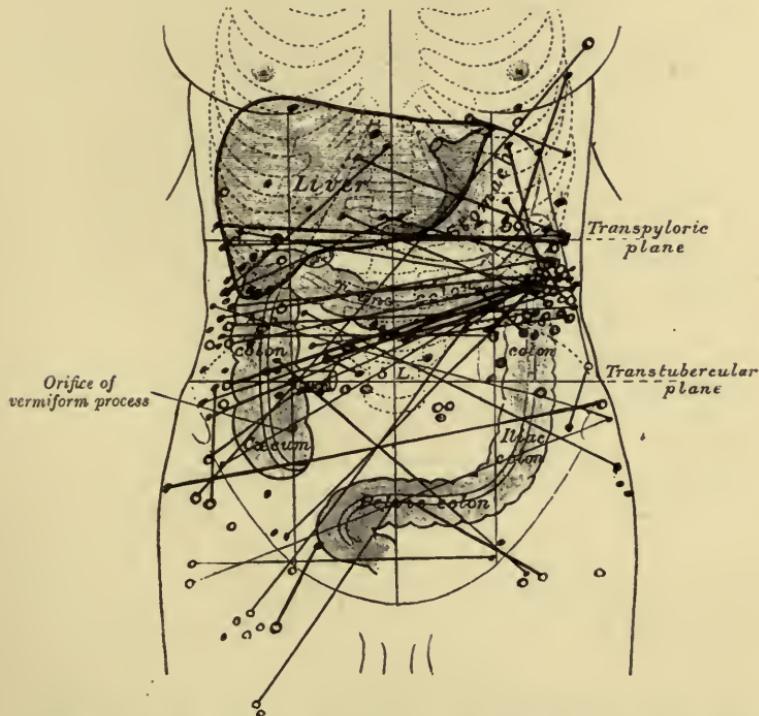

FIG. 4.—Chart of cases too seriously wounded to be submitted to operation, all being fatal. A black dot represents an anterior wound, a circle a posterior wound ; the track of the projectile is shown by a line.

hæmorrhage. In only five cases is shock noted as the cause of death, viz. : (1) One perforation of ileum with a shattered os ilium. (2) Multiple wounds of small gut ; no blood in belly. (3) Shock ; no other details. (4) Wound of ileum and sigmoid ; peritonitis and shock. (5) Wound of rectum and small gut.

In one case retroperitoneal sepsis was noted as the cause of death. In only three instances was peritonitis deemed the cause

of death. The number of times the small gut was injured is the salient feature in the series, and perhaps another interesting point is that the stomach figures five times. Wounds of the solid organs were responsible for death in twelve instances.

TABLE III.—*Showing Injuries in Moribund Cases.*

Stomach and kidney	2
,, ,, colon	1
,, ,, liver	1
,, ,, ,, spleen, and pancreas	1
Small gut	27
,, and colon	4
·, ,, rectum	2
,, ,, embolism from wounded carotid	1
Colon	5
,, and kidney	1
Rectum	2
Liver	8
,, and spleen	2
,, ,, kidney	1
Spleen and kidney	1
Bladder	3
Paraplegia and acute dilatation of stomach	1
Prolapse of stomach, small gut, and colon	1
,, ,, colon, and spleen	1
,, small gut	1
,, spleen and splenic flexure	1
Wound of internal iliac vein	1
	—
Total cases	68

TABLE IV.—*Showing the Number of Times Individual Organs were wounded.*

Stomach	5
Small gut	34
Colon	10
Spleen	4
Liver	13
Kidney	5
Rectum	4
Bladder	3
Pancreas	1

Cases recovering without Operation. — Fig. 5 was obtained by plotting the entrance wound and the track of the missile, when known, in cases that recovered without operation. Most of these wounds lie within the liver area. The chart also shows wounds in various other parts of the abdomen; and their recovery, as will be seen later, is most probably due to
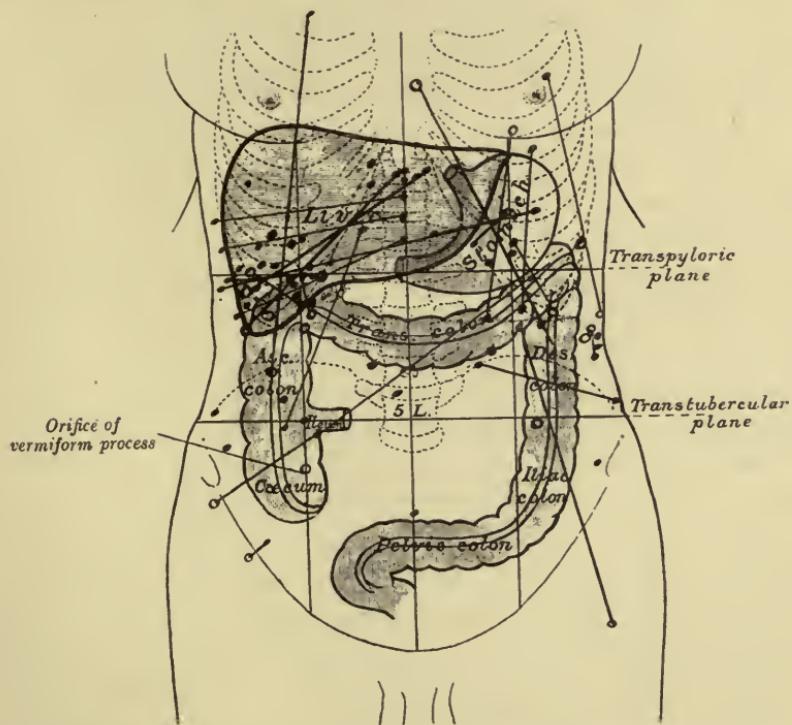

Fig. 5.—Chart of cases that recovered without operation. Dots, circles, and lines have the same significance as in Fig. 4.

the fact that the hollow viscera had escaped although the abdomen had been penetrated.

Wounds above the Transpyloric Plane.—Antero-posterior wounds in this region are among the least serious of all abdominal penetrations. Side-to-side wounds are, as has been seen, serious, especially if they are far back. Wounds which enter the abdomen from above downwards, and which may be described as vertical, are also serious. Sometimes one has great surprises, and one case may be mentioned in which a soldier

was shot accidentally by a revolver bullet which entered above
the blade-bone and was taken out of the gastro-colic omentum ;
no hollow viscus was injured, and the man made a complete
recovery.

Epigastric Wounds.—In the mid-line true antero-posterior
wounds are seldom seen in hospital. The lesser curvature, the
œsophagus, and a large portion of the stomach lie within this
area. Wounds in this region were usually accounted as stomach
wounds, and recovery often reckoned as an instance of spon-
taneous healing. Operation has proved that in some cases the
projectile misses the stomach and perforates the gastro-hepatic
omentum. Naturally, wounds in this region will often involve
both surfaces of the stomach. Epigastric wounds have not
maintained their reputation as favourable lesions.

Antero-posterior Hypochondriac Wounds.—On the right the
liver will be perforated, on the left the cardiac area of the
stomach as well as the greater curvature. Towards the lateral
line of the body the kidneys, spleen, and splenic flexure will be
involved in addition to the liver and stomach.

Oblique Epigastric and Hypochondriac Wounds.—When the
wounds are oblique from side to side, no distinction can be drawn
between the two regions, as projectiles traverse both. These
wounds are decidedly more dangerous than antero-posterior
wounds. Indeed, they become more fatal as they get more
oblique. On the right side a greater length of liver is traversed,
and the dangers of hæmorrhage and sepsis are increased. On
the left the stomach is perforated more and more obliquely,
until a point is reached where the axis or flight of the bullet
becomes parallel to the anterior wall or greater curvature. The
result is either a long slit or a double hole through which the
contents leak freely. The spleen, kidney, and splenic flexures
will also at times be involved with the stomach. Wounds of the
kidney and spleen are a fairly common combination, those of the
stomach and spleen a rare one.

Vertical Epigastric and Hypochondriac Wounds.—These are
nearly always more or less inclined downwards and inwards,
but cases occur of almost vertical wounds in which both the
entrance and exit wounds are on the anterior surface of the body

and almost vertically above one another. When a projectile passes in these directions, the injury of the liver or stomach is complicated by one of the colon or small intestine, for the missile often passes below the transpyloric plane. In one such case both the antrum of the stomach and the transverse colon were almost completely cut in two. Vertical wounds on the lateral surface of the body appear at first as thoracic. On the right side they are not so dangerous, since they may only traverse the liver ; but on the left they may wound the stomach, spleen, and liver.

Posterior and Lateral Wounds of Hypochondriac Regions.—As usually met with, these are single entry wounds. Such wounds between the left axillary lines often exhibit the omentum protruded through the ribs. On the left the spleen, kidney, and the splenic flexure may be wounded, and therefore such wounds are more dangerous than those occurring on the right. They are difficult to treat, as access to this region is not easy, and the infiltration of the retroperitoneal tissue renders detection of the colon perforation difficult even if the spleen and kidney are successfully dealt with. Posterior wounds in the costo-vertebral angle, or through the lower ribs, cause similar injuries to those on the lateral body surface.

WOUNDS BETWEEN THE TRANSPYLORIC AND INTERTUBER-CULAR PLANES.—This region is a very fatal one (see Fig. 4). Above the umbilicus the injuries resemble to a considerable degree those met with above the transpyloric plane, but below the umbilicus we have largely to deal with small intestine injuries.

Antero posterior Wounds.—Again, these are seldom met with in the mid-line. On either side of the spine, in the upper part of the region, perforations through the transverse colon are met with, and are usually easily dealt with. Lower down, but still near the middle line, the small intestine is wounded, and the gravity of the cases at once rises. In the lumbar region, wounds of the ascending or descending colon are encountered. If the peritoneal surface alone is involved, the danger is not so great, provided no large destruction of the wall has taken place. Wounds of the left lumbar region are more dangerous than those on the right, for here the coils of the jejunum overlie the great

bowel. There is another point of interest about flank wounds, and that is the possibility of the escape of the colon or peritoneum from injury owing to the thickness of the muscles of the abdominal wall at this point. As a matter of fact, the colon, especially the descending, when seen from the front lies farther from the lateral line of the body than might be supposed. Wounds entering the back in this region are more fatal on the whole than those that enter the front : not only do they wound the viscera, but they plough up the retroperitoneal tissue, or cause it to be stripped by blood infiltration. When such a course is taken by a bullet or small shell-fragment, the external wound may be insignificant, but a hidden leak into the retrocolic tissue may cause death before sufficient relief has been given by a free incision or a colostomy.

WOUNDS BELOW THE INTERTUBERCULAR PLANE.—These include wounds through the hips, buttocks, and thighs. All are very serious.

Antero-posterior Wounds.—In the hypogastric region these are dangerous on account of small-gut lesions. Mid-line wounds frequently come to operation, as there are no great vessels to cause death before hospital is reached. If the bladder is full it will be involved, but it is a somewhat remarkable fact that such injuries are not very common. The pelvic colon and the rectum may be injured. Towards the side of the body, in the iliac regions, wounds of the cæcum and iliac colon are encountered.

Side-to-side Wounds.—These may involve the cæcum, small gut, and pelvic and iliac colons. Such injuries are very dangerous, the small-gut wounds being nearly always multiple. The pelvic vessels may also be injured, and cause death from direct hæmorrhage.

Semi-vertical Wounds.—In the *Lancet* of December 18th, 1915, I called attention to the dangerous nature of these injuries, and many have since confirmed this opinion. They are caused by missiles which enter the buttock, perineum, or thighs. In the early days of the war a wound in the buttock or thigh was often unconnected in the surgeon's mind with the possibility of an intestinal lesion. These wounds nearly always cause

multiple injuries of the small intestine ; the bladder and rectum are also involved. Such wounds are nearly always accompanied by pain in the abdomen soon after their receipt. The soldier often thought that he had been hit in the abdomen, while the surgeon was not inclined to accept this diagnosis ; the fatality of such cases was partly due to the abdominal injury being overlooked, and time lost.

Possibility of Escape of Viscera in Penetrating Wounds.

It has always been a much debated point as to whether a projectile could traverse the peritoneal cavity without wounding the hollow viscera. Makins held that it was possible from his experience in South Africa. Others denied the possibility. There has never been any doubt that the liver and kidneys could be damaged without involving other organs. The point that required settling was the escape of the stomach in the upper part and the small intestine and colon in the lower. Those who believed in treating abdominal wounds by rest and starvation pointed to cures, by this means, of patients in whose cases it appeared, by a study of the track of the bullet, that a hollow viscus must have been perforated. Makins held that there was a possibility of recovery in cases of colon injury, but that small-intestine lesions were always fatal.

Until quite recently, when cœliotomy became the routine treatment of abdominal wounds, a proof that such escape was possible was almost wanting. The classical case of Cheatle's was often quoted as a proof, but there were people who were not convinced by it.

Fig. 6 shows a chart of cases in which the abdomen was opened and explored, and no hollow viscus found injured. The abdominal cavity was usually full of blood. This blood came from two sources : (1) the vessels of the omentum, mesentery, or abdominal wall (deep epigastric usually) ; in these cases the hæmorrhage was arrested by ligature of the vessel : (2) from cracks in the peritoneum raised by a retroperitoneal effusion of blood ; here little beyond clearing the abdomen could be done, for experience has shown that such collections of blood are best left alone.

In many cases there were bruising and tears of the peritoneal and muscular walls of the stomach or intestine. These tears and bruises explain the cases where a fæcal fistula or an intra-peritoneal abscess has appeared some time after the receipt of the wound.
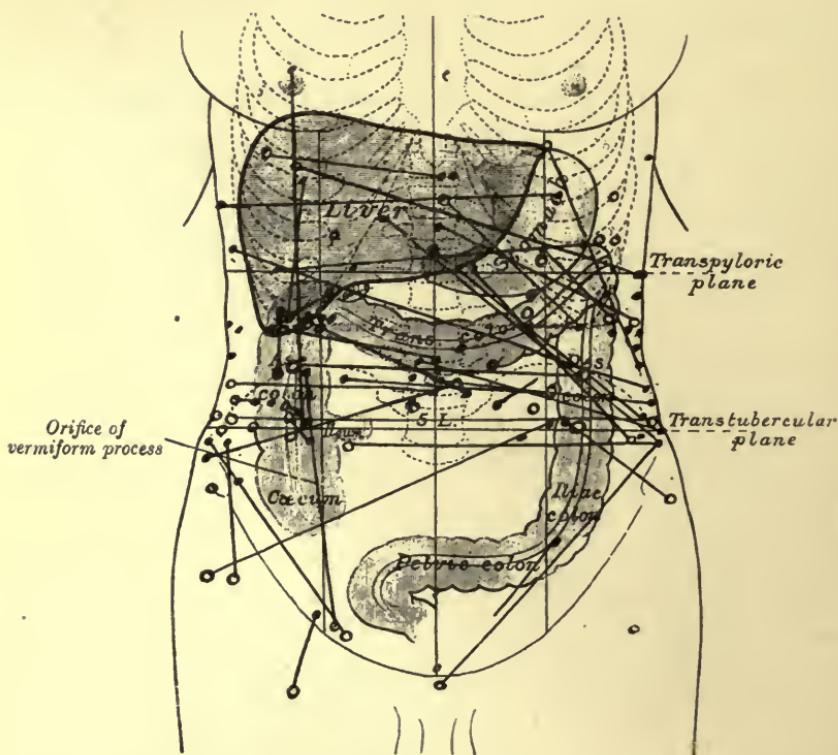


Fig. 6.—Chart of cases in which cœliotomy was performed and no hollow viscus found injured. Dots, circles, and lines as in Fig. 4.

The Possibility of Spontaneous Recovery after the Perforation of Hollow Viscera.

It is quite true that people do recover spontaneously after wounds of the hollow viscera, but the number is very small. Those that recover may be said to be the exceptions that prove the rule. The following are instances :—

(1) *Healing of Stomach.*—Makins * describes a case in which

* *Journ. of the Royal Army Medical Corps*, January, 1916.

a wound of the posterior surface of the stomach was firmly sealed to the pancreas and spleen ; death resulted from secondary hæmorrhage. Lieutenant-Colonel T. R. Elliott and Captain Herbert Henry have also described cases of spontaneous healing. I myself have seen a healed wound of the stomach in a patient who succumbed to other injuries. Lastly, Captain Green-Armytage actually closed the abdomen in a case where a hole in the stomach was impossible of suture, and a cure resulted. Although such healing does result, it must be looked upon as more of academic than of practical interest. No surgeon would nowadays use such cases as an argument in favour of abstention.

(2) *Healing of Colon.*—There have been frequent instances of recovery after wounds of the vertical colons, as has been insisted on by Makins, who attributes such a favourable result to the intense local reaction produced by the contents of this portion of the bowel.

(3) *Healing of Small Intestine.*—For the history of the following remarkable case I am indebted to Surgeon-General Bowlby and Captain Bell :—A soldier was shot from side to side through the body at the battle of Loos. He was not operated on, and recovered. There was nothing special about his convalescence. He was again shot in the abdomen in the battle of the Somme, and was operated upon. When the abdomen was opened, several perforations of the small intestine were found in the neighbourhood of a mass of adhesions. The wounded and adherent segments were excised, and the man made a good recovery. On slitting up the adherent coils an entero-enterostomy was found between two adjacent loops ; in addition, there were several small herniated diverticula of the mucous membrane, obviously pointing to closure of the previous penetrations. This case is of interest because the process of healing corresponds to that which Captain H. Drummond has shown to be the case when the intestines of rabbits are perforated, and put back without suture. The herniated mucous membrane remains herniated, and gradually becomes covered with a layer of lymph, which slowly organises and seals the hole, the herniated mucous membrane still forming a diverticulum.

Rupture of Viscera outside the Actual Course of the Projectile.

(1) *Rupture of Viscera by Contusion of the Abdomen.*—As in civil life, one meets with a fair number of abdominal injuries caused by horse kicks. Others are caused by falling in of dug-outs, by burial of men by shell explosions, and by blows of fragments of wood which are hurled about. They present nothing out of the common, and the injuries seen are the same as some in civil life. Captain J. B. Haycraft had one case, which may be mentioned, in which the *post-mortem* examination on a man who died after such burial showed numerous contusions of the small intestine, without rupture.

(2) Similar injuries are caused by large shell fragments, usually shell caps, and several cases of the latter injury have been seen in which rupture of the intestine was accompanied by extensive contusions. Some years ago Makins wrote a paper on this subject, and he came to the conclusion that such injuries are caused by the bowel being caught between the unyielding posterior abdominal wall and the oncoming object. This supposition is strengthened by the association of bruises with perforations in the case above quoted.

(3) *Cases in which the Viscera are damaged by Indriven Bone Fragments.*—(*a*) There are many cases of injury to the liver and spleen by the driving in of fractured ribs. (*b*) The caecum, the ascending and descending colon, and also the small gut in the pelvis, are all apt to be injured by small bony spicules driven in through the peritoneum. Although the projectile itself does not penetrate this membrane, it is important to remember this possibility, because when such wounds are explored it is most probable that the small holes caused by the bony fragments will be overlooked, and the peritoneum assumed to be inviolate.

(4) *Rupture of Solid Organs by Indirect Violence of a Passing Projectile.*—Such injuries are not uncommon. Fig. 7 shows a picture of a kidney in which many cracks in the capsule were produced by a missile which did not touch the organ. The spleen is often ruptured in this manner, and sometimes the liver. In one case the diaphragm was intact, but on opening the peritoneum much blood escaped, and there was an extensive

tear in the spleen. In another case the diaphragm was ruptured over a small area, the blow being a glancing one. There was a corresponding wound on the outer surface of the spleen, and from this wound there ran in all directions radiating fissures in the capsule, showing that the spleen had been burst by the indirect force exerted upon it.
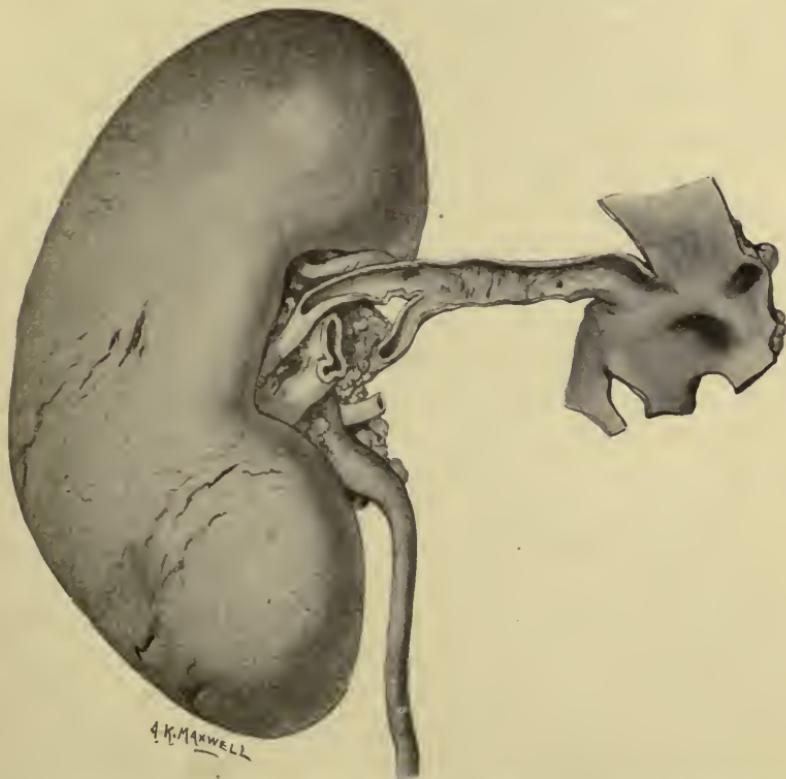

Fig. 7.—Kidney: indirect effects of gunshot—organ fissured, concentric fissures run across the intima of the renal artery. Bullet entered left buttock, traversed sacrum and fifth lumbar vertebra, and passed out through right psoas, keeping behind the colon; the track was quite clear of the colon and kidney. (Specimen prepared by Captain J. S. Dunn.)

(5) *Rupture of Hollow Organs by Indirect Violence.*—Cases of this class have been reported by Owen Richards, John Fraser, J. W. Dew, and others.

(*a*) Rupture of the intestine by a bullet without penetration. The first case was that of a man whose recti were divided almost completely by a bullet. The wound was explored, and

the posterior rectus sheath found intact. As there were no symptoms, the abdomen was not opened ; the man died. At the *post-mortem* a careful search failed to show any rupture of the peritoneum. There were three holes in the small intestine which lay immediately under the wound in the abdominal wall, showing the gut had not moved, although more than twenty-four hours had elapsed since the receipt of the injury. Fraser's case was that of a man wounded by a piece of shell in the right iliac fossa, the cæcum being found bruised, and a small hole in the mesenteric border of the ileum. In Dew's case the projectile had cut through all the abdominal wall except the peritoneum, through which the cæcum could be seen. As there were no symptoms, the abdomen was not opened, but the man died from a ruptured ileum. Stevenson, Shaw, and Mackenzie have described a rupture of liver and jejunum by a missile that did not open the abdomen.

It would seem that these ruptures may be caused in two possible ways : (1) When an object such as the abdomen and its contents, made up of layers of varying toughness, is sharply hit, more friable layers underneath may give way, while the more resisting overlying layers remain intact. (2) This may be termed the " paper-bag " theory, the viscus being ruptured by a smart blow in a similar way to that in which an inflated paper bag is burst on being hit. There is no proof that this happens, but it is rather a seductive theory. The following case of J. Fraser's is interesting in this connection : A bullet penetrated the abdomen just below the umbilicus ; there were no symptoms at first, but when they arose later on, cœliotomy showed a ruptured bladder. The bladder was apparently out of the direct line of the projectile.

There is another possibility which must not be lost sight of : a man may fall to the ground, or against some object, when he is hit, and the ruptured intestine be due to the blow thus produced, and not to the actual missile which was the indirect cause of the fall.

Mechanism of Wound Production after Penetration.

The multiplicity of the wounds of the small intestine has raised some doubt as to their method of production, especially

in the case of bullets, where widely different types of wound are
seen.   The question arises whether a bullet pursuing a straight
course can cause these injuries, or whether we must invoke a rota-
tion of the bullet, or a bursting effect.   If a bullet is rotating
quickly on a transverse axis, it could easily produce complete
division of the gut, but if it is rotating quickly enough to pro-
duce such injuries, it is hard to see how it could at the same
time produce small perforations.   Some support is given to the
rotation theory by the retention of many bullets ; one knows
that their flight is unstable at the end.   If the rotation theory
is correct, one ought to have some evidence of this rotation at
the entrance and exit holes.   As a fact, it is impossible to
establish any relations between the size of the entrance and
exit wounds in the skin and the amount of damage done to the
intestine.   As to the possibility of a bursting effect (paper-bag
theory) it is impossible to make any definite statement.   In a
case operated on by Captain Hamilton Drummond there was
a rupture of the small intestine between the leaves of the
mesentery which was not found until the intestine was laid
open.   The position of the rupture was outside the track of
the bullet (see also Fraser's case of ruptured bladder).   One
must remember, however, that the intestine is not greatly
distended by either gaseous or fluid contents.   It seems almost
impossible to believe that anything of the nature of a hydraulic
or pneumatic effect could be produced.   In this connection the
following case is pertinent : A soldier was shot through the
abdomen, the muzzle of the rifle being in contact with the body.
The entrance wound was close beside the umbilicus, and the
exit wound at a corresponding point behind.   The bullet passed
by the side of the vertebral column and made three type lesions
in the jejunum.   He was promptly operated on, and made a
perfect recovery.   If any pneumatic or hydraulic effect is to be
expected, it should have been found in this case.   I am rather
inclined to think that these different types of wound are caused
by the varying state of distension of the small gut.   As is well
known, one meets with lengths of the small intestine alter-
nately distended with air and collapsed.   If the bullet strikes
a distended portion, it will perforate it or cut a hole in it.   If it

strikes a portion which is collapsed, the intestine is so small that the bullet is large enough in diameter to divide both coats the whole breadth of the bowel.

Some support is given to this assumption by the behaviour of the large gut. Perforations are here much more common than large tears or complete division. When complete division does occur it is in the portions of the gut that are often found

FIG. 8.—Small intestine divided in seven places by a rifle bullet. Small wound of entrance in epigastric region. Bullet lay free within abdominal cavity. Parts resected. Patient died a few hours after operation. (*Brit. Journ. of Surgery.*)

small and collapsed, namely the transverse and descending and pelvic colons. The ascending colon and hepatic flexure nearly always show perforations.

In considering this subject great interest attaches to a lecture by Professor S. G. Shattock, an abstract of which, as it appeared in the *British Medical Journal*, December 15th, 1917, is appended below.*

* For the complete lecture see *Proceedings of Royal Society of Medicine*, 1917.

Professor S. G. Shattock, F.R.S., observed that, from the strictly pathological standpoint, the new factor introduced into gunshot injuries, as injuries, was the velocity of the penetrating body ; they were otherwise contused and infected wounds like those produced by other foreign bodies, although their number and variety gave them special surgical features. Under the term " explosive effect " more than one thing was included : it was applied (1) to the increase of damage due to shattering of the bullet, (2) to the additional injury resulting from the comminution of a bone and the dispersal of its fragments, and (3) to the damage resulting from the high velocity of the missile. The last alone possessed any special pathological interest. It had been asserted (Professor Dr. K. Stargardt) that the British bullet was an expanding one, in consequence of the core being composed of aluminium at the point, and elsewhere of lead ; that on striking (bone at least) the momentum of the lead carried this forwards over the harder aluminium, and so split the mantle. In order to test this the author had had recourse to the following experiment : The bullet was fired at a distance of 20 feet through a sternum into cotton waste, from which it was recovered without having struck any second object. The sternum was selected in order to obtain a direct hit. The bullet was found to have undergone no distortion whatever. Two sterna were then spliced together and shot through in the same way ; the bullet on recovery was found quite undamaged. In solid organs the results of high velocity were best seen in the liver when perforated by rifle bullets at close range. The typical injury was a perforation accompanied with radial fissuring of wide extent. Even here the elimination of extraneous factors, such as obliquity of impact, or turning of the missile in transit, damage due to the introduction of clothing, could only be effected by experiment. In firing through suspended sheep livers at 20 feet with a service rifle and pointed bullet, this was the form the injury took ; the mechanical action of gas produced by explosion was eliminated by the distance. In analysing the physics of this result the wave of compressed air produced by the bullet (demonstrated by Professor Vernon Boys in instantaneous photographs) was

wholly negligible. The speaker had found that if tense screens of tissue paper were shot through at 20 feet with a service rifle, the hole was but little larger than the bullet ; were the air wave of any moment, the paper would obviously have been widely rent. Sir Victor Horsley, in commenting upon the cavitation produced in his experiments of firing into clay, attributed more importance to the spin of the bullet (centrifugal action)
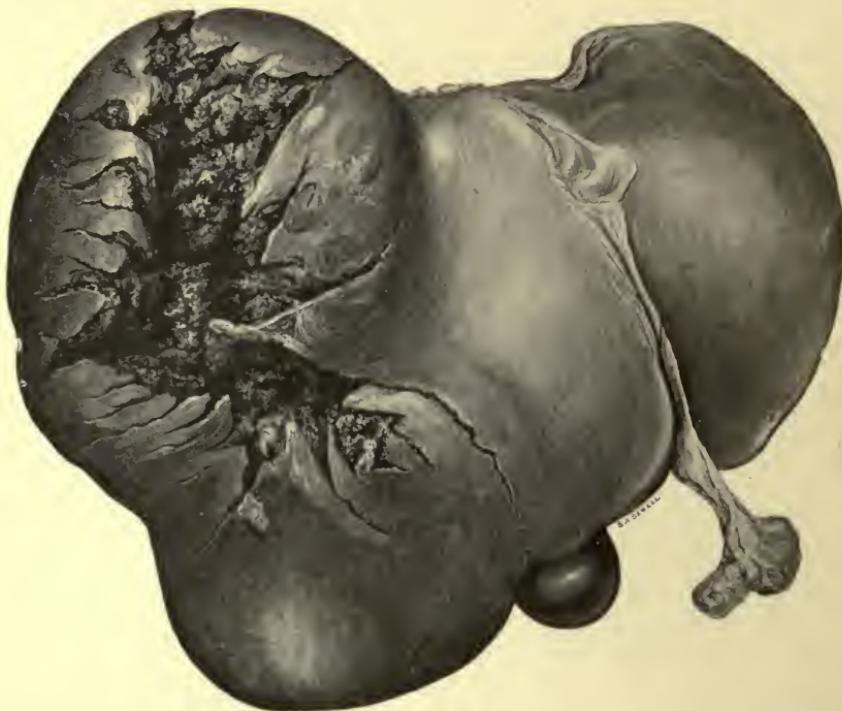
FIG. 9.—Rupture and laceration of the right lobe of the liver by bullet discharged at short range. It perforated the right hypogastric region from before backwards. Soldier died of hæmorrhage. (*Brit. Journ. of Surgery.*)

than to its forward movement. The speaker had carefully inspected all the plaster casts made from the clay in these experiments, and was unable to find the evidence of such rotation ; the coarser ridges (representing shallow fissures in the clay) as well as the finer markings were longitudinal. The turn of the present British bullet was only one in 10 inches, yet explosive effects were observable in, for example, the sheep livers before referred to, where the thickness was only $1\frac{1}{2}$ inch, which would

reduce the rotation to less than a fifth. In only one specimen—
in the collection on view in the Royal College of Surgeons—
were the divergent fissures curved ; here the bullet had tra-
versed the body of the third lumbar vertebra first, and must
have had some altogether exceptional twist imparted to it. The
question was thus reduced to one of forward velocity. This was
well shown in the liver by the fact that in perforations caused
by shell fragments at low velocity a patulous tunnel alone
resulted. The same difference was beautifully demonstrated
in Horsley's casts, where the distal half was only of the calibre
of the bullet, the explosive or dilating effect being limited to the
proximal. In the case of the clay, the ready entrance of air
from behind allowed of its cavitation ; in the liver, where this
was out of the question, the cavitation was represented by radial
fissuring produced by the passage of the wave through an in-
compressible semi-solid medium. In hollow organs the produc-
tion of explosive effects depended upon their contents, other
things being equal. Such effects from rifle bullets were not
observed in the stomach or intestines by reason of the com-
pressible air and gas which they contained, nor in the lung,
for the same reason. The contusion, unattended with breach
of surface, found not rarely in such organs, was possible from
their extreme mobility and compressibility. The longitudinal
wounds produced at times in the intestine by intact bullets
were explained by the wall having been struck axially. In the
case of the bladder, the contents of which were incompressible,
explosive results were now and then encountered. In the
collection there was a bladder perforated by a rifle bullet which
entered through the buttock without fracturing bone, and
eventually escaped above the pubes ; in the posterior wall of
the bladder was an entry admitting the finger ; the anterior
wall (exit) was rent from top to bottom. The speaker had
obtained similar explosive results by firing through ox bladders
distended with water, a service rifle being used at 20 feet.
The result was a simple hydrodynamic one, and due to the wave
imparted to a mobile and incompressible fluid in a confined
space. If the bladder was empty, or only lightly filled, the
rending on the far side did not take place. In arteries and veins

no hydrodynamic effect was observable, whether in unilateral or bilateral perforation. Its absence was possibly due to the indefinite continuity of fluid above and below the stricken spot and to the remarkable strength of both kinds of vessels. The speaker had been unable to produce either macroscopic or microscopic damage of the inner or middle coats of the human common iliac artery under the highest pressure that could be exerted with a dissecting-room syringe. In regard to the skeleton, the rigidity of the structure concerned was a complicating factor. If the upper part of the shaft of the tibia was compressed over a small area in a vice, however *slowly* the compression was made, extensive comminution and fissuring ensued far beyond the spot compressed. Nevertheless the same rule held : the greater the velocity of the missile the greater the damage.

The classical example of explosive effect was the well-known widespread comminution of the skull when bilaterally perforated by a rifle bullet at close range. The effects due to the gas of explosion had, of course, to be excluded. The results of suicidal shooting were thus liable to lead to false conclusions : a rifle fired into the mouth with blank cartridge would produce extensive comminution. This factor was, however, easily eliminated ; the speaker had found, too, that sheep skulls with the brain *in situ* underwent extensive comminution when shot through at 20 feet with a service rifle, the foramen magnum being freely open. The result was not, properly speaking, hydraulic, but hydrodynamic—that is, it was not due to a generalised and equable internal pressure, but to the sudden impact of the incompressible cerebral substance against the interior of the cranium. A simple experiment, devised by the speaker, would emphasise this. A large, flat-sided " cocoa tin " was shot through in the empty state at 20 feet with a service rifle ; a circular entry and exit of about the diameter of the bullet resulted. A second tin was filled with water and shot through, the *lid being removed ;* the entry was small and circular, the exit widely split, with large triangular flaps of the metal completely everted. The speaker had obtained pronounced explosive effects also in sheep skulls inverted and filled with water, the foramen magnum being freely open ; if the

skull was shot through in the empty condition, a circular entry and exit alone resulted.

Comparative Frequency of Wounds in the Different Viscera.

The following table gives some idea of the relative frequency with which different organs in the abdomen are wounded :—

TABLE V.—*Relative Frequency with which Different Abdominal Organs are wounded. From a Total of 965 Cases.*

Viscus.			No. of Times wounded.	Viscus.			No. of Times wounded.
Small gut	..	..	363	Spleen	..	..	54
Colon	..	..	252	Bladder	..	..	45
Liver	..	..	163	Rectum	..	..	21
Stomach	..	..	82	Pancreas	..	..	5
Kidney	..	..	74	Ureter	..	..	3

State of the Alimentary Canal in respect of its Contents.

(1) *Stomach.*—The amount of food in the stomach is dependent on the time that has passed between the last meal and the time of wounding. The escape of contents depends on this, and on the size and situation of the wound. If the wound is a small one, and near the lesser curvature or the cardiac end, there will be little found in the abdomen ; if, on the other hand, the wound is large, and near the greater curvature, extravasation may be very considerable. It is only in connection with the stomach that free gas has been seen to escape from the wound or to be present in the abdomen.

(2) *The Small Intestine.*—The small intestine is usually empty, and it is hard to fix any definite relation between the amount of its contents and the time of the last meal. It is in a very favourable condition from a surgical point of view, even more so perhaps than after the elaborate preparation which has been till recently the rule in civil operative practice. The collapse of the gut is not due to escape of gas, for free gas is not found in the abdomen.

The usual absence of any large amount of intestinal contents seems to be due to a more rapid passage of food along the

tube than is usually considered normal, or else to a very complete digestion. Otherwise, considering the number of cases treated at various intervals after meals, the presence of contents should be more frequent. It is the absence of contents, more than anything else, that accounts for the little extravasation. Should the intestine be loaded, there is a large escape.

In one case it was possible to get the exact time of the last meal. A man had a dinner of bully-beef and Clarke's beans at 1 p.m. ; he was hit at 6 p.m., and operated on at 10 p.m. All evidence goes to show that after a wound, digestion and vermicular movements cease, so that one can assume the state of the intestine at 10 p.m. was the same as that at 6 p.m. The operation showed that the man was wounded $3\frac{1}{2}$ feet from the cæcum, and here the bowel contained much fluid and solid matter, including Clarke's beans, which were extravasated to a large extent. This case was under the care of Captain H. Drummond.

Another interesting observation was made by Captain John Fraser. A party of soldiers was shelled in billets just after the midday meal, which consisted of large quantities of tea. There were several cases of abdominal wounds. The amount of fluid in the abdomen in some cases of wounded small gut was remarkable, and in contrast to the usual condition. It looked as if the fluid contents had passed rapidly into the small intestine. The stomachs themselves—to judge by one case, at all events—were still full of food. It is interesting to note that extravasation is apparently more common in vegetarians than in meat eaters. (Major C. H. Barber, I.M.S., Gunshot Wounds of the Abdomen during the Siege of Kut : *Lancet*, Jan. 20, 1917.)

(3) *The Large Intestine*.—This is often loaded, and presents a great contrast to the small intestine in this respect. This fact, no doubt, is due to the sedentary life in the trenches. The loaded state of the bowel may have some relation to the infectivity of the contents. On the other hand, a constipated condition tends to limit the escape of the contents.

State of the Alimentary Canal in respect of the Nervo-Muscular Mechanism.

When considering this subject a sharp distinction must be drawn between the appearances seen before, and after sepsis

has produced its effects on the intestine. It is with the former that we are at present concerned.

The Stomach.—This is often normal both as regards its size and the thickness of its walls. On the other hand, it is by no means rare to find it dilated. This dilatation is, as a rule, of moderate dimensions, but may be of considerable extent, and occasionally a condition of acute dilatation is present. This last condition is seen both in peritoneal and retroperitoneal wounds, and with and without spinal injury. Apart from actual dilatation seen in the course of operation, many cases after operation present the clinical symptoms of the condition, which is relieved, as a rule, by stomach lavage, but sometimes ends fatally.

An experiment performed by Captain H. Drummond and myself may be of interest in this connection. A dog was given a weighed meal containing bismuth. A skiagram showed that the organ emptied itself in six hours. The experiment was repeated, with the addition that the animal was anæsthetised for half an hour. There was no delay in the emptying of the organ. Another experiment was performed similar to the last, but in this instance a resection and suture of intestine was performed. The stomach had not begun to empty itself in six hours.

The following case shows that the loss of motile power is not altogether dependent on a penetrating wound : An officer had his dinner at 7 p.m. Immediately afterwards he took his platoon into the trenches. On the way up some obstruction occurred in the communication trench, and the officer got out of the trench to put matters right. His femur was shattered by a bullet at 10 p.m. The next morning at 11 a.m., having had no food in the interval, he was given an anæsthetic that the wound might be treated in the ordinary way. He vomited his dinner practically unaffected by digestion.

The Small Intestine.—This presents alternate lengths of moderate distension and collapse, and on the whole the calibre of the tube is on the small side of that usually seen in civil practice. Sometimes this condition is exaggerated, and the appearance of the abdominal contents when first seen on opening the belly is comparable, as Fraser has said, to that of a formal in body. Very occasionally a wounded segment of the gut presents

a local dilatation at the lesion (see Fig. 11). Sometimes the upper jejunum shares in the dilatation of the stomach.

The intestines remain motionless a considerable time after injury. This is shown by the fact that when the missile has taken a comparatively superficial course, and wounded the gut as it lies against the anterior belly wall, the injured part is still found in the same place after a considerable interval. The same thing has been noted in those cases where the gut has been ruptured without abdominal penetration, and death has ensued (see page 33). I have seen the wounded gut still in the place in which it was hit after thirty-six hours. The adhesions that quickly form after wounding no doubt anchor it in place after motility has reappeared. Sir William Watson Cheyne described a similar case in the South African War, where the gut remained in position after three days.

Drummond and Fraser have raised the interesting point as to whether an extensive injury of the small intestine may not, to a certain degree, assist in its own cure by causing a more profound paralysis than does a more trivial injury.

It is at present impossible to say definitely how long on the average the gut remains paralysed ; the only other observation bearing on this subject is that peristalsis has been seen in the jejunum eleven hours after injury.

It is possible that a persistence of the traumatic paralysis of the gut is the source of trouble after a resection, and two cases apparently of this nature have been reported by Richards and Fraser.

Some experiments seem to show that in animals, after a resection, the upper segment of the intestine remains paretic after the lower one has regained its power, and that the last part of all to become normal is that in the immediate neighbourhood of the resection. It is possible to start a peristaltic wave in the lower segment some time before it can be originated in the upper, and even when a contraction can be brought about in the upper segment, it fails to move, remaining as a stationary constriction of the gut.

CHAPTER III.

Where to Operate.

The Time Factor.

Table VI. was compiled by dividing the time between the receipt of the wound and the performance of the operation into two-hourly periods, and noting whether cases were sent to the Base or succumbed to their injuries. It mainly shows two things : (1) it gives some idea of the time in which cases are got out of the trenches and submitted to operation ; and (2) it shows the effect on the mortality of the time which has elapsed between the receipt of the injury and the performance of the operation. It will be seen that most cases arrive some time between six and ten hours after the receipt of the injury. Up to six hours the chances are in favour of the patient ; after this period they are always against him.

To the table have been added a few cases in which patients have died after an unexpectedly short period, and also a few of those in which recovery has followed the lapse of a long period between the receipt of the wound and the operation. So far the limit in successful cases has been forty-eight hours for a resection of the small intestine, and thirty-six hours for a suture of the colon, and for a suture of the stomach.

Table VI.—591 *Cases showing the Effect of Time on Mortality.*

	Hours.											
	2.	4.	6.	8.	10.	12.	14.	16.	18.	20.	22.	24 and over.
To Base ..	3	30	75	55	34	19	7	4	11	4	0	27
Died ..	2	30	53	59	41	23	10	12	15	11	4	52
Total ..	5	60	128	114	75	42	17	16	26	15	4	79

To Base.		Died.	
Hours.	Injury.	Hours.	Injury or Cause of Death.
24	Colon	6	Small gut and hæmorrhage.
57	Bladder	6	,, ,, ,,
24	Sigmoid	5	Gas gangrene of abdominal wall.
30	No visceral injury . . .	3	Small gut and peritonitis.
48	,, ,, . . .	4	Stomach and duodenum.
26	Jejunum	4	Small gut and hæmorrhage.
15	Stomach	4	Stomach.
65	Rectum, extraperitoneal .	6	Multiple wounds of small gut.
72	Colon fistula	3	Colon.
		4	Spleen, excision of, for hæmorrhage.

Where to operate on Abdominal Cases.

The time factor table shows that the sooner a man is operated on the better. But there is another important factor. The wounded man must be kept quiet and well nursed.

In certain sectors of the line it would be physically possible to operate on him at the Regimental Aid-Post or Advanced Dressing Station, but it would be under the most disadvantageous circumstances. After operation nursing, as usually understood, would be impossible. In addition the man would be under constant shell-fire or close to our own guns, both of which would have a very bad effect on him. Again, there are not enough surgeons to staff such places.

It is therefore necessary to operate on him at a special operating centre placed between the Advanced Dressing Station and Casualty Clearing Station or to take him back to a Casualty Clearing Station.

In deciding this it must be remembered that the time occupied in passing from the Advanced Dressing Station to the Casualty Clearing Station is usually a very small part of the time that elapses between the receipt of the wound and the time of arrival at the Casualty Clearing Station.

If therefore the Casualty Clearing Station is reasonably far

forward (10,000—15,000 yards from the line), it is, except in some special cases, the best place for the operation.

It may be well to say here something about the mobile operating vans. They have loomed somewhat largely in the public mind and have been a good deal discussed. The idea is that you can have the motor van fitted out as an operating-room, and that such a van should seek the patient rather than that the patient should be brought to the theatre. It may be stated at once that this idea is impracticable, and much more time would be spent in getting to the patient than is now spent in getting the patient to an ordinary Clearing Station. When speaking of a mobile hospital van it must be understood that one does not include in this category a theatre which can be rapidly erected, adequately warmed and lighted, such as the French and Italians use on many occasions ; such units are only meant to be mobile in much the same degree as the Casualty Clearing Station was intended to be mobile.

On the other hand, special hospitals are very good when Casualty Clearing Stations cannot be got near the line. I will briefly describe some.

The first one was situated in a bleaching mill ; it was about 5,000 yards behind the firing line, and took all the abdominal wounded of a certain corps. It was formed by sending an operating surgeon and an anæsthetist and four nursing sisters to supplement the *personnel* of a Field Ambulance which was situated in this building. It had a very good theatre and a large ward, which in cold weather was steam-heated. Here cases frequently arrived within two hours or less, the patients being carried straight from the spot where they were wounded to the hospital, irrespective of what Division they belonged to This hospital was never pressed and never had the strain of a large fight placed upon it. It continued to do its good work until the enemy began to pay attention to a bridge which crossed a canal on whose banks the mill was situated. Then it was shifted a bit to one side and to another building which was much less commodious. There it remained until the area passed out of the jurisdiction of the Army. The sisters and operating surgeon and anæsthetist were then moved to a

different part of the line, and were re-established in the ugliest
château it has been my misfortune to see. It was situated
about 9,000 yards behind the line and in a very much more
difficult sector as far as evacuation was concerned. Here it
continued to do excellent work, although the railhead and a
coal-mine near by were continually shelled, many of the shells
coming into the garden uncomfortably close to the house. It
was closed at last, as a Casualty Clearing Station was opened
near by. This hospital was also never pressed ; and the results,
as in the last, were very good.

The third hospital was opened in a Field Ambulance just
before the onset of a big battle ; and it was arranged that all
the abdominal wounded from a Corps should be brought to it.
As a matter of fact, in the stress of battle the wounded from
two Corps were carried to it. The result was that the place
was heavily worked, and the results were not so good as in the
last two.

A fourth abdominal hospital may be mentioned, because
there are some lessons which can be learnt from it. Experience
had been gained by the overwork of the last hospital, and
adequate arrangements were made to prevent it. The *personnel*
of this particular hospital was adequate for its needs. In
addition it was arranged that when the hospital became full
the wounded should be sent on to a Casualty Clearing Station
situated somewhere farther back. The result of this arrange-
ment was that all the abdominals that had the good fortune to
be admitted were well and rapidly treated.

The lesson to be learnt from the experience gained at such
hospitals can be summarised as follows : that in quiet
times such hospitals opened at Field Ambulances by the
provision of an operating surgeon and a few sisters can do
magnificent work and save life. If, on the other hand, such
hospitals are to be opened in times of battle, it is necessary to
have very much the same *personnel* that is allowed to a Casualty
Clearing Station. Unless a large number of beds are provided,
the hospital soon becomes full, and the *personnel* is not used to
its full capacity.

On the whole the better plan is to evacuate all the abdominals

to the front line Casualty Clearing Stations, while allowing the less seriously wounded to pass to those in the rear. Care must be taken to make the *personnel* of the hospital receiving abdominal cases adequate for its work ; otherwise some cases will only be admitted to wait longer than if they had been sent farther back. Taking all cases that enter a Casualty Clearing Station, it is not possible to put many more than twenty-five such cases on an operation table in twenty-four hours. If the proportion of abdominal cases· admitted is high the number of cases that can be operated on is very much lower.

Arrangements at the Present Time in the French and Belgian Armies.

It has been said above that the French and Belgians went through the same experience as ourselves. Since the line became fixed operation has been the accepted practice. The French have established advance abdominal hospitals by means of what they call motor surgical ambulances ; these are really hutted theatres which can be easily erected, and they are extremely complete in their arrangements. These hospitals, which correspond with our Advanced Operating Centres, are pushed rather farther forward than is the practice in the British Army, and have, I believe, met with a large measure of success.

Professor Tuffier also informs me that the French have tried the experiment of "dug-out" operating centres situated some hundreds of metres behind the trenches, where it is possible to operate on the wounded in from a half to two hours after the accident. He adds—which is of considerable interest—that, with the very large attacks they have had and the great number of wounded they have had to be dealt with, this arrangement has not given very good results, for the reason that the wounded have arrived late, and very often these ambulances have been unable to deal with the numbers of wounded they have received.

The Belgians have followed suit to a certain degree, and have pushed their abdominal operating centres far forward, and have lately provided special ambulances for the transmission of the operated man to the hospitals farther back. I have not so far ascertained what measure of success they have had, but the Belgians are favourably situated in that they have large base

hospitals very close behind the firing line. They have, too, had no large offensives. The Italians have used mobile operating ambulances in the same manner as the French. In the mountains where the fighting has taken place evacuation is extremely difficult; and such centres have, therefore, proved exceedingly useful.

CHAPTER IV.

DIAGNOSIS AND TREATMENT CONSIDERED GENERALLY.

Diagnosis of Intraperitoneal Damage.

THIS is determined in three ways : (1) by inspection ; (2) by experience ; (3) by symptoms.

With all possible care, and an extensive experience, and a full appreciation of the numerous fallacies, it is frequently difficult to make sure that the wound is penetrating. If it is difficult when there is an entrance and exit wound, it is still more so when there is only one wound. It may be that shock, hæmorrhage, rigidity, or rapid pulse will be present ; in some cases which are received early, there may be no such guides. It may be said that the wound of a hollow viscus has in itself no symptoms ; it is hæmorrhage or peritonitis which give the danger signal.

(1) BY INSPECTION.—Antero-posterior wounds are the easiest to judge. The only point to be remembered is the thickness of the flank muscles. Below the transpyloric plane a wound with the entrance on one side of the middle line, and an exit near the lateral body line of the same side, is very often non-penetrating, or has just opened the peritoneum. Above the transpyloric line such a wound, owing to the rounded form of the thorax, is almost certain to be penetrating. The bullet which passes in and out between the semilunar lines probably does not open the abdomen, while the one that passes in and out outside these lines probably does. In the longitudinal direction, a bullet which enters near the costal margin, and emerges above the groin, will most likely traverse the abdomen. Where it is a question of single wounds, there is really no guide except the symptoms, as it is usually impossible to tell the direction of the projectile. Much help is afforded by an X-ray examination in such cases. One case may be quoted as showing the difficulty of judging where a missile has gone—a man was shot beside the umbilicus. The shape of the wound suggested a bullet. The

area was a dangerous one, so it was determined to explore the abdomen. As the wound was in a convenient situation, the exploratory incision was made through it. It was then found that the rectus muscle was torn the length of the incision. This was enlarged downwards to the pubes, the muscle being much torn down to the bone, but the sheath and peritoneum were intact. The bullet had passed down behind the pubes. As there were no symptoms, nothing further was done, and the case, after an interval of several days, was sent to the Base doing well.

The possibility of rupture of underlying organs in such cases must be carried in mind, and it is well to err on the side of opening the abdomen.

(2) By EXPERIENCE.—This has shown that one has to be very careful in making a negative diagnosis, and it has also shown the wisdom of operation in doubtful cases.

Bomb wounds require some notice under this heading. The fragments into which a bomb is broken on explosion are often very small, but so high is their velocity that they have very great power of penetration. The wounds may be so small and insignificant that it sometimes takes real strength of mind to explore the abdomen, although the symptoms point to the possibility of visceral involvement. The number of these wounds makes individual exploration impossible, and the only way of settling the matter is to explore the abdomen by a well-placed incision, irrespective of the situation of the wounds.

(3) By SYMPTOMS.—These may be enumerated as follows : appearance ; pulse ; vomiting ; hæmorrhage ; rigidity ; pain ; tenderness ; subjective sensations ; shock.

Appearance.—Usually a man hit in the abdomen looks ill. Sometimes he appears to have no serious lesion. Often he is shocked and cold, in spite of blankets and hot bottles, with which he has been surrounded in the ambulance. Sometimes he is apathetic and quiet, sometimes restless, sometimes from pain, sometimes from distress. He may be blanched or of a fair colour, even normal in appearance. Before rapid evacuation was the rule one was struck by the fallaciously good facial expression of some of these cases, and often experienced a shock, on taking up a

man's hand, to find it cold and clammy, and the pulse running or even not palpable. Such cases invariably die, and operation only hastens their end.

Pulse.—A rapid pulse, a pulse that does not fall, or a rising pulse, is an indication for operation. A slow pulse is not necessarily a contra-indication unless the wound is in a non-dangerous area such as the liver.. I have seen a man with a pulse of 60 with four holes in his small intestine four hours after receipt of the injury. A rapid pulse is caused by loss of blood, and later on by peritonitis and sepsis. It does not seem to have any very definite connection with the number of lesions of the intestine. The pulse often falls with rest and quiet. Often a falling pulse is more an indication of the possibility of operation than a contra-indication to operative measures.

From Table VII. one can see the general average pulse of a man wounded in the abdomen. A pulse of 100 is very common, and, on the whole, gives a good prognosis. A pulse of 120 seems to be a critical one, for the mortality is here rapidly mounting. Of 145 patients with a pulse over 120 only 16 recovered.

TABLE VII.—*To show Effect on Pulse of Prognosis. Total Number, 577.*

Pulse up to and including	60.	70.	80.	90.	100.	110.	120.	130.	140 and over.
To Base ..	1	7	23	30	108	27	37	7	9
Died ..	1	2	13	18	39	38	88	37	92
Total ..	2	9	36	48	147	65	125	44	101

Mention may be made here of unexpected results which some pulse-rates show. A man having a pulse of 160 with a wound in the liver went to the Base without operation. A pulseless man recovered after his bladder and small intestine had been sutured. A man with a pulse of 60 died from the effects of hæmorrhage although the bleeding was stopped by operation. A man with a pulse of 90 died of gas gangrene in the abdominal wall. Another

with a pulse of **80** died of peritonitis on the third day. One case with a pulse of **160** recovered, the reason for the rapidity being an extraperitoneal hæmatoma of the bladder, which was drained.

Vomiting.—Wounds of the stomach nearly always lead to vomiting, and very often to hæmatemesis ; but vomiting is also met with in all kinds of wounds other than abdominal ; and, beyond the fact that its absence shows that the stomach is most probably not involved, it has no special significance or indication.

Hæmorrhage.—This will be dealt with more fully later on (p. 130). It is sufficient to say here that, with the exception of blanching and a rapid pulse, both of which may be produced by other causes, the classical signs, such as restlessness, blindness, or air hunger, are usually absent. Hæmorrhage gives the ordinary physical signs ; but, as is well known, these are not very helpful, for to produce them the amount of blood may have to be very great.

Rigidity.—This is a very constant, but varying symptom. It is seen (*a*) in low thoracic injuries ; (*b*) in wounds of the abdominal wall, pelvic floor, and even of the thigh ; and (*c*) with visceral injuries.

(*a*) The rigidity produced in the abdomen by low thoracic injuries is well known, and it renders diagnosis very difficult, especially in cases where, from a study of the track, the bullet may or may not have entered the abdomen. One such case I well remember, in which a man, hit in the lower right axillary region, presented a universal rigidity of the abdominal wall, accompanied by considerable pain. His condition otherwise was not bad. It was determined to watch him, and he was put to bed and kept quiet for three hours. At the end of that time the rigidity had become board-like. There was considerable increase in his pain, and his pulse-rate was slightly accelerated. An abdominal exploration showed that, after all, the abdomen was uninvolved, and that the only possible injury was a wound of the liver on its extraperitoneal surface. Curiously enough, this man died of tetanus a week later. A piece of shell loose in the pleural cavity will also harden the abdominal muscles.

I do not know that there is any royal road to diagnosis

between a thoracic and abdominal wound. It is often noticed that, if a man is placed in a semi-recumbent position, the abdominal rigidity tends to abate if the injury is only thoracic. Captain B. C. Maybury has an idea that superficial abdominal tenderness is rather a feature of thoracic wounds.

(b) In the wounds of the abdominal wall the rigidity is apt to be local, and, as a rule, does not give rise to very much confusion. Contusions of the abdomen do present considerable difficulty, and in cases which recover without operation marked rigidity, an extremely rapid pulse, and pallor may all be combined. Wounds of the pelvic floor, even when not penetrating, will produce a reflex hardness of the anterior wall, as may wounds of the upper thigh.

(c) Injuries both of the solid and hollow viscera are accompanied by rigidity. This rigidity seems to be brought about in two ways : (1) it is a reflex protective measure after the receipt of any wound ; (2) it is also brought about by irritation of the peritoneum, either by blood or infection. It is largely independent of the amount of peritoneal infection, and occurs in an extreme form without any naked-eye appearance of inflammation. Under such conditions it is generally accompanied by very great pain.

Rigidity often occurs when there is blood in the abdomen the source of which is only a wound of the mesentery or omentum. It is not, as a rule, very marked in these cases, and tends to subside with time, in contradistinction to that due to peritonitis, which is progressive. One occasionally sees a somewhat rigid and tumid condition of the abdomen in cases arriving late ; such a condition is usually only a sign of hæmorrhage which has been arrested ; such cases are usually best left unoperated.

Considered clinically, (1) rigidity may be slight, and this generally or locally. (2) It may be confined to one part, and if this spreads it generally means an intestinal lesion. (3) Alternating rigidity. During examination the abdomen is sometimes soft and sometimes hard. This is a very puzzling condition, and its indication is not very clear ; it is sometimes accompanied by extensive injuries. (4) Apprehensive rigidity, if one may use the term. Here, although the abdomen looks soft and moves on

respiration, it at once hardens when the hand approaches to palpate. As a rule it is accompanied by no serious injury. (5) Board-like rigidity is most puzzling when accompanied by a slow pulse. If there is extreme pain, it nearly always means that there is a wound of the intestine. (6) Complete absence of rigidity ; this, when accompanied with obvious penetration of the abdomen, is often, as has been pointed out by Taylor and Meyer, a very bad sign. One case of such a condition may be quoted : A man was hit in several places on the abdominal wall by small fragments of an aerial bomb within a few yards of an Advanced Operating Centre. He was admitted within a few minutes of the injury. He was shocked, but not cold. His pulse was 130 and very poor. His abdomen was perfectly lax, and continued so till death, about twelve hours later. He complained of much epigastric pain. Three hours after wounding his condition seemed hopeless, as his pulse was small and feeble (130), and his extremities blue and cold in spite of artificial warmth. Notwithstanding his bad condition, he lingered on for many hours. A *post-mortem* showed that he had three small holes in the jejunum and about two pints of blood in the belly cavity. This case shows the difficulty in determining whether to operate or not. Had he been transfused, he might have stood an operation. A lax abdomen may exist with hollow viscera lesions and the patient be in good state.

It may be here stated that morphia in moderate doses seems to have very little effect on the state of the abdominal wall.

The Spinal Abdomen.—One has to be on one's guard not to be misled by the slightly rigid and tumid abdomen which is met with in cases of spinal injury, and especially when such injuries are accompanied by vomiting. This state of the abdomen is sometimes caused by a distended bladder, but it may be present without it.

Tenderness.—This has very much the same value as the tenderness met with in penetration of the intestine due to disease. The point of maximum tenderness may coincide with the position of the gut lesion.

Pain.—Is nearly always present in some form or another ; it varies from almost uncontrollable agony to nothing more than

discomfort. It usually comes on at once. There does not seem to be any particular relation between the amount of pain and the amount of injury.

Subjective Sensations and Shock.—Are dealt with later (p. 135).

Care of the Patient before Operation.

In Transit to Hospital.—Captain Moore has pointed out that a man wounded in the abdomen is more comfortable if he can be put in such a position that his abdominal muscles are relaxed. The patient should be covered up as soon as possible and kept warm by adequate blankets and hot water bottles or hot bricks (see " Treatment of Shock," p. 138).

Morphia.—The subcutaneous method of administration is the best. The buccal method is not reliable. If the tabloid is dissolved in the mouth and absorbed by the mucous membrane, it acts quickly. There is, however, the risk that the tabloid is swallowed and action thereby delayed. It thus happens that a further subcutaneous dose is given to allay the continuing pain. After a time the swallowed morphia begins to act and produces its own effect in addition to that of the dose given under the skin.

Soldiers have in addition carried morphia, with which they have dosed themselves, unknown to the medical officer. Morphia used beyond the point of relieving pain is, in my opinion, prejudicial to the patient.

Initial $\frac{1}{2}$-grain doses are to be avoided; a $\frac{1}{4}$ or $\frac{1}{3}$-grain dose is nearly always sufficient.

It is very important that the amount, the method of administration, and the time be all entered in the patient's tally.

Morphia should be given as soon as possible after receipt of the wound. It allays the apprehension that men feel when lifted high on a stretcher, possibly above the edge of the trench.

The Withholding of Fluids.—There is no reason why fluid should not be given in reasonable amounts; its withholding causes great distress to the patient, who is very likely suffering already from a lack of fluid in his body. Bicarbonate of soda can with advantage be given at this stage.

In Hospital.—When a patient arrives at an operating hospital, the question of immediate operation has to be considered. It is better to put the man to bed and watch his condition for a little than to immediately subject him to operation. It is quite true that hæmorrhage is the great danger, but still experience has led me to think that on the whole a little rest does more good than harm. The interval is used to improve the man's condition.

First and foremost as a remedial measure is the warming of the patient. This is by far the best treatment of shock, and greatly transcends in importance the administration of stimulants, of whatever nature, either by the mouth or hypodermically. It is very remarkable to what an extent the treatment by drugs has fallen in favour.

It is often wise to warm the patient up on the stretcher on which he arrived by placing a lamp beneath it and forming a hot chamber by hanging blankets over the sides and ends. If it should be decided to undress him, this should be done on such a stretcher. When undressed he can be placed in bed and heated by the electric or hot air cradle. If heat, rest, and morphia do not improve a man's condition, it is doubtful if transfusion or infusion will produce any effect.

Fluid can be introduced into the system by the mouth, by the rectum, subcutaneously, or intravenously ; it depends upon the state of the patient and his capabilities of reception. If the patient cannot drink the intravenous method is by far the best and surest. The fashionable method of subcutaneous saline is practically valueless in a shocked man. If the patient can drink, it is well to increase his alkaline reserve by giving a drachm of bicarbonate of soda in water and follow it up with sweetened tea or coffee. If unable to retain fluids by the mouth, an infusion of bicarbonate of soda, 2—4 per cent., is recommended, unless there has been much bleeding. If hæmorrhage is feared, transfusion of blood is by far the best restorative. Many believe that transfusion is best given during or at the end of the operation. If blood is given before operation, the opening of the abdomen should not be delayed for long. The same applies to all intravenous injections on account of their

tendency to retard hæmorrhage. The transfusion may be followed by an infusion of bicarbonate of soda (2—4 per cent.). If blood is not available, an infusion of 6 per cent. gum acacia in a 2 per cent. bicarbonate solution is a good substitute.

The actual moment for performing the operation must be left to the individual judgment of the operator. If the man does not respond at all, the question must be decided whether it is best to operate at once or whether it is worth operating at all. The pulse (see Table VIII.) will give some help. Frequently even as much as six or eight hours' rest will produce such improvement that an operation is possible where at first the case seemed hopeless.

Operation.—The operation table must be adequately warmed, and the length of the operation curtailed, not by undue haste, but by careful preparation. Whatever anæsthetic is used, cyanosis must be avoided.

Question of Operation.

Experience has shown the wisdom of operating as a routine measure, and it is now mainly a question of excluding the cases on which it is best not to operate.

It can be admitted that this line of treatment involves operating on some patients who have no visceral injury and on some in whom the wounded parenchyma of solid organs has ceased to bleed.

On the whole "Look and see" is a better maxim than "Wait and see."

It may be useful to enumerate those cases which are best left alone.

(1) *Cases in very Bad Condition.*—There are, of course, many cases which no surgeon would feel himself justified in operating on ; but there are many border-line cases, which some surgeons would leave, and others would feel constrained to submit to operation. Here the personal equation comes in, and whether he operates or not must be left to the surgeon to decide. The pulse will be a valuable guide. The bolder surgeon may get the worse operative mortality and yet save more lives.

(2) *Cases shot high up in the Abdomen in the Liver Area.*—Such

cases on the whole do very well if left alone, so long as there are no symptoms of hæmorrhage ; in fact, hæmorrhage and the retention of a large missile are the only reasons for operating on liver cases.

(3) *High Abdomino-thoracic Wounds on the Left Side.*—The type of wound more especially referred to is that which enters near the mid-line behind, and emerges somewhere towards the posterior part of the axilla about the level of the sixth to the eighth rib. These wounds are sometimes accompanied by symptoms suggesting stomach involvement, but on the whole do not seem to do badly. Operative interference does not afford very much help, as wounds high up in the cardia or near the œsophagus may be almost impossible to close, or, if they can be reached, involve such disturbances as are likely to lead to a fatal result. If operation is decided upon, the transpleural route is the best.

(4) *Cases arriving late.*—I am inclined to put down twenty-four hours as a usual limit within which a primary operation is likely to be successful ; hæmorrhage by this time has ceased, and operation is only likely to spread infection if the bowel has been perforated, and to hasten the end. There are some cases in which operation may be thought advisable, namely, those with a fair pulse but with vomiting, the operation being performed with an idea of getting over the " obstruction " by short-circuiting or an enterostomy. Operations of this class have nearly all been fatal.

The operation of simple supra-pubic drainage is an absolutely useless disturbance.

Wounds on Back to be first Treated.

Marshall has shown that rolling a patient over, after cœliotomy, to reach wounds on the back of the body causes a great fall in blood pressure. Such wounds, if they are to be treated, should be attended to before opening the abdomen.

The Incision.

(1) *Its Site.*—This must be planned rather with a view to dealing with the probable nature of the injury than with any reference

to the wounds. With an in-and-out wound we know the course of the projectile, and can form a fair estimate of the organs likely to be involved. With a single wound this is practically impossible, and here an X-ray apparatus is invaluable, as it enables us to place the abdominal incision in the best possible situation.

To give an instance of the value of X-rays : suppose there is a single entry wound near the semilunar line. Without an X-ray examination the only thing is to open the abdomen in the middle line and ascertain the course of the missile ; this involves an exploration of the entire abdomen, and in the end it may be found that the only viscus injured is the colon at its peritoneal reflexion. The exploratory procedure will have exposed the whole abdomen to the danger of contamination. On the other hand, an X-ray picture would have located the missile in the loin, and shown at once that a horizontal explora· tory wound would have met all the circumstances of the case, and possibly saved a life.

Vertical Incisions.—A paramedian incision is the standard method of opening the abdomen, and it should be used in all cases unless there is some distinct indication to the contrary. It is always better to prolong it than to make lateral right-angle extensions. The length should be about 8 inches ; if in doubt, it is better to use a longer one, as free access means a great increase in celerity and less manipulation of the intestines outside the belly cavity.

In some antero-posterior wounds towards the lateral line of the body, a rectus-sheath incision has something to recommend it : the colon can be reached and the field of operation limited. It is not, however, a good incision to close, and divides many nerves.

Transverse Incisions.—In those cases where the missile has perforated the body from near the mid-line to the loin, whether this direction is shown by an entrance or an exit wound or by the aid of a skiagram, the transverse incision, either horizontal or parallel to the upper or lower abdominal limits, is much to be recommended. If more room is required, it can be obtained by cutting the rectus sheath, but leaving the rectus muscle intact.

Such an incision allows free access to the hepatic and splenic flexures and the vertical colons, to the kidney, and to the spleen. It allows removal or exploration of the kidney without rolling the patient far over—a great advantage, for Marshall has shown that such movement is followed by an alarming drop in the blood pressure at the close of an abdominal operation. It also permits an easy examination of the upper small intestine, and of the lower with a little more difficulty, if necessary. It is the only incision that allows the ascending and descending colons to be easily and properly repaired, and, in addition, is a convenient situation for an artificial anus. It is not a convenient incision for the stomach, except for that portion situated near the spleen.

A similar incision starting behind, and prolonged forward if necessary, can be used with advantage in exploring posterolateral wounds of the body. A subcostal incision is also good in some liver wounds. Such incisions suture easily and heal kindly. In some cases of wounds in the back of the loin, it is better to open the abdomen in the mid-line and make sure that the peritoneum has not been involved. If it has, the wound is closed and the loin opened up, and the necessary steps are taken to deal with the condition found. It is always very important, when there is a possibility of a colon wound, to do everything to prevent contamination of the general abdominal cavity.

(2) *Its Closure.*—The method of closure must depend on the condition of the patient. If this is critical, it must be by through-and-through sutures. If there is time, an attempt should be made to close the peritoneum separately; many of these wounds suppurate, and it is impossible to prevent the suppuration extending to the intestines if the peritoneum is unsutured. If the patient's condition allows, the wound can be closed in layers, but in every case there should be at least three through-and-through supporting stitches which only miss the peritoneum.

Suppuration in the operation wounds has been a trouble. It may be partly due to defective technique; but in many cases one has to remember that the blood in the abdomen, which must well out when the cavity is opened, is full of micro-organisms.

Various methods have been tried to prevent infection, but with no great success. On the whole, however, there has been a good deal of improvement. It is curious that the same difficulty is found on operating on acute appendix abscess, where the peritoneum can readily combat the septic condition in which it is left, while the abdominal wound falls a victim to the bacilli.

Treatment of the Peritoneal Cavity.

(3) *Abdominal Drainage.*—Opinions differ about this, and personally I never use it, nor do I believe that it has any points to recommend it. When speaking of abdominal drainage, I mean the ordinary drain to the pelvis or loin. It is quite another thing to tie a small drain to a suture line which one mistrusts, the idea of which is to form a local track in the case of a leak.

(4) *Flushing the Abdomen.*—Some surgeons favour this procedure, and it has something to be said for it when the abdomen is full of septic blood. At the same time it is difficult to carry out efficiently without exposure of the intestines. In small local infections without blood it is not to be recommended. The cold produced by ether is sufficient to damn it, even if it could cleanse the abdomen ; a small amount used to produce leucocytosis may find favour with some.

Post-operative Treatment.

I do not know that there is anything particular to be done to the patient after the abdomen is closed. Rest and quiet and the avoidance of all needless disturbance are to be aimed at. The question of infusion or transfusion will naturally arise, and in some cases may be beneficial. Most people treat their cases in a semi-recumbent position. Personally, I would let the patient choose his own posture. As to the administration of morphia, it is better to give it than withhold it if the patient is restless or in pain.

Most interest turns on the condition of the bowels. Castor oil, calomel, and pituitrin, all have their advocates. There can be no doubt that pituitrin is a very fine purgative, especially if injected into the muscles ; sometimes it requires to be helped by a glycerin enema. Like all other purgatives, it is dependent

for its action on a healthy condition of the musculature of the bowels, and if this is paralysed either by shock or sepsis, it will fail to act. For my own part, I am not particularly anxious about the opening of the bowels, and am fairly convinced that the bowels will not give trouble if the case is going to do well ; if not—and it is mostly a question of peritoneal sepsis—no purgative is of any real avail. A good deal of discomfort has been needlessly inflicted by attempts to make the bowels act.

Dilatation of the stomach is a fairly common complication, and is to be treated by gastric lavage, repeated if necessary.

A word may be said here about the progress of the patients after operation. Putting aside those who do well from the first, and those who never look like recovering, the post-operative cases may be roughly divided into three classes : (1) Patients who do well for thirty-six hours or so, then go through a critical period, with abdominal distension, vomiting, and a rising pulse. They may eventually recover or succumb. (2) Those who are troubled by sickness continuing from the operation, but in whom the sickness diminishes and the pulse-rate falls. (3) Those who vary in an astounding manner from day to day, so that one can have no certainty of the ultimate result. This condition is often independent of the condition of the bowels, which may be acting. These are the cases spoken of by Sampson Handley in his paper in the *Lancet*, April 8th, 1916. The cases referred to by him were those of pelvic peritonitis, in which the lower segment of the bowel is mostly affected ; in the cases under discussion, unfortunately, the infection is often in the upper portion of the abdomen. The two classes of case do not seem to be quite on a level, even if we admit that the dilatation of the upper segment is a septic and not a nervous phenomenon. However this may be, it is a most difficult point to determine whether operation is likely to do good or not. One sees so many patients go through a critical period and recover that one fears to proceed to secondary operation for fear of turning the balance against them. It has been tried on several occasions, with very little success. If it is done, the method advocated by Sampson Handley seems to be the method of choice.

CHAPTER V.

Wounds of Hollow Alimentary Organs and their Treatment.

Wounds of Particular Organs.*

Œsophagus.—Wounds of the œsophagus are rarely seen, while those of the pharynx and trachea are more common. The rarity of such wounds is due to the fact that antero-posterior wounds involve the spine and transverse wounds the great vessels. Some of the lower thorax wounds which are accompanied by vomiting may be wounds of the œsophagus. In one case of a fatal abdomino-thoracic wound it was found that the œsophagus had been torn just as it passed through the diaphragm. Such wounds must always be dangerous, as, even if diagnosed, access to them is exceedingly difficult either by way of the abdomen or across the chest.

One curious case may be quoted where a man was hit in the back about the fourth right interspace. He was treated for a thoracic wound, as there were no localising symptoms. Two days later he passed *per anum* the core of a bullet, and the day following the mantle.

Stomach.

Frequency.—In 965 operated cases the stomach was perforated eighty-two times. In fifty-five instances it was the only hollow viscus damaged.

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* (*a*) The number of times that injuries of solid organs complicate injuries of other organs (both hollow and solid) is probably understated, though the proportion of such complicating injuries of solid organs to one another is approximately correct.

(*b*) In speaking of the causes of death, no reference has been made to injuries other than abdominal; but in many cases the fatal result must be largely put down to injuries other than those of the abdomen.

(*c*) The lesions of hollow organs enumerated in the tables and in the text are perforative lesions. Every single viscus was bruised or had its outer coats injured on many other occasions.

SITUATION OF THE INJURY.—This is shown in Table VIII. :—

TABLE VIII.

Site of Wound.	Alone.	With other Hollow Viscera.
Anterior wall	27	8
Posterior wall	5	1
Anterior and posterior walls	14	10
Greater curvature	2	1
Lesser curvature	2	1
Cardia	2	1
Near œsophagus..	2	—
Lesser curvature and posterior wall ..	1	—
Wall, not stated	—	5
Total	55	27

The number of times both walls have been perforated and other hollow viscera (both small and large gut) wounded is rather remarkable, when one remembers how innocuous antero-posterior epigastric wounds were supposed to be.

The fact that the posterior wall may be wounded alone, or in conjunction with the posterior surface of the transverse colon, is of importance, as neither of these places is visible unless a special search is made ; such wounds have been missed at operation.

ASSOCIATED WOUNDS OF OTHER ORGANS :—

Hollow Viscera.—Small gut, 19 ; colon, 13 (colon and small gut together, 5).

The jejunum is the part of the small gut most frequently hit, very often within a short distance of its commencement. These high injuries are especially caused by side-to-side wounds which catch the bowel as it lies high up in the abdomen in front of the kidney. When the projectile pursues a more vertical course, the ileum is also injured, or injured alone.

. The transverse colon is, more frequently than any other part of the great gut, injured along with the stomach ; but parts so far distant as the pelvic colon and cæcum have also been hit. The splenic flexure escapes more often than one would expect. Sometimes, in addition to the transverse, the ascending or

descending colon is wounded. Such wounds are caused by projectiles having a highly inclined side-to-side course.

Solid Viscera.—Liver, 15 ; spleen, 5 (4 fatal) ; pancreas, 3 ; kidney, 4.

A few examples of complicated injuries may be given :—

Anterior wall—spleen—kidney (died).

Stomach—pancreas—kidney (died).

Stomach—liver—kidney (died).

Anterior and posterior walls—transverse colon—small gut (died).

Anterior wall—transverse colon—jejunum (died).

Lesser curvature—descending colon—liver (died).

Anterior wall—cæcum.

Anterior wall—descending colon (died).

Lesser curvature near œsophagus—top of spleen (died).

Anterior wall—lower pole of left kidney.

The few occasions on which a stomach and spleen wound occurs, considering the close association of these viscera, are remarkable and suggest that such injury is very fatal.

NATURE OF THE WOUNDS.—The stomach affords many types of wound, nearly all easily explained by the nature of the projectile and the course it takes. Sometimes the stomach wall is exposed by the carrying away of the anterior abdominal wall. At other times prolapse of the stomach takes place, accompanied by that of the colon, small gut, and spleen.

Bullets passing in an antero-posterior direction make small perforations. Shrapnel balls cause larger perforations, the edges of which are more excoriated than is the case with bullet wounds; the larger size and rounder form of the ball cause it to bruise the wall before it bursts its way through. Shell and bomb fragments make wounds commensurate with their size and shape. When the axis of the flight of the projectile is more or less parallel to the walls of the stomach, the wounds become larger—sometimes a linear slit, sometimes a linear slit followed by a perforation, to which the name of " note of exclamation wound " may be given. The linear type of wound is nearly always on the anterior surface. When the projectile passes in through the epigastrium and out by the axilla, the slits tend to

become parallel to the greater curvature. When the missile takes a more vertical course, the wounds are inclined at an angle to the greater curvature, and the anterior wall of the stomach, or its antral portion, may be almost completely divided. Projectiles hitting the greater or lesser curvature in an antero-
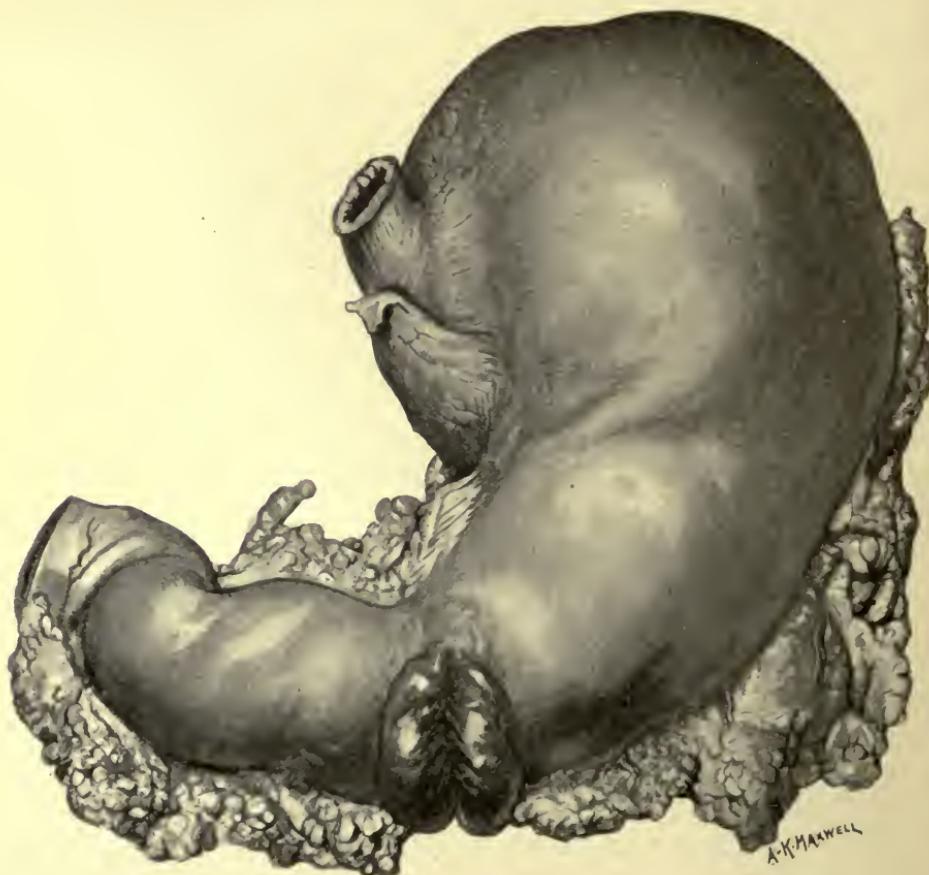
Fig. 10.—Bullet wound of anterior wall of stomach. The wound extended half an inch on to the posterior wall. The right gastro-epiploic artery was divided. Under care of Captain Hamilton Drummond. (*Medical Society* and *Brit. Journ. of Surgery.*)

posterior direction sometimes cause rather extensive V-shaped injuries involving both walls. Occasionally the wound is a valvular one, preventing the escape of the contents.

Bruises or cuts in the peritoneum or muscular coats are not infrequently met with.

Gangrene of the wall has resulted from injury to the gastro-splenic omentum.

The mucous membrane does not pout when the wounds are small; but in the case of linear wounds it becomes extruded just as it does when one incises the stomach wall in doing a gastro-jejunostomy.

Bleeding.—Wounds of the stomach are accompanied by very severe hæmorrhage, which may come from the organ itself or from vessels or organs near it. The hæmorrhage, as a rule, does not come from the actual wall, but from the vessels as they run up and down its surface. The bleeding may take place either into the stomach or into the peritoneal cavity.

SYMPTOMS.—Vomiting is a very constant feature; in fact, the stomach is the only viscus which almost always furnishes this symptom. One is often surprised that vomiting is possible, when the size of the wound in the organ is considered. There is sometimes an escape of gas from the wound, but no particular diagnostic value is to be attached to the presence or absence of liver dulness. The escape of contents has already been dealt with. It should be noted that bile may escape from a stomach wound.

TREATMENT.—Operation is to be advised in almost all cases. The only possible exceptions are those cases of low thoracic wounds where it is judged from the track of the missile that the stomach is wounded near the œsophagus or in the upper air-containing part. Some such cases do get well by them-selves, and one rather hesitates to operate because of the difficulty encountered and disturbance caused.

The standard incision is a paramedian one. The closure of wounds of the horizontal portion is easy, but the farther to the left and the nearer to the cardia the more difficult does the operation become. This difficulty points to the advisability of using the transpleural route when wounds of the cardia are in question, especially if the missile has entered through the thorax and has only involved the immediate neighbourhood.

As a rule, one can tell if the posterior wall is likely to have been involved. If this is the case, or if there is any doubt, the posterior surface must be explored through the gastro-colic omentum in the usual way. The suture of such wounds may be

very difficult. Wounds of the lesser curvature involving both coats are also troublesome to suture. There is no need to excise the wounds unless they happen to be very ragged. Gastro-enterostomy may be necessary in cases of wounds dividing the antral portion or the duodenum, or in some cases of narrowing of the stomach; this should only be done in cases of very evident necessity.

PROGNOSIS.—The maximum period of successful suture after receipt of the wound is thirty-six hours, and the prognosis depends largely on the amount of hæmorrhage that has taken place, and on the association of other wounded organs. The amount of peritonitis present does not depend very directly on the length of time between the injury and the operation.

Possibility of Spontaneous Recovery.—This has already been admitted.

SECONDARY COMPLICATIONS.—A secondary hæmorrhage was not a very uncommon event, and was met with as early as the fifth day ; it is much less frequently seen now than formerly.

In the *British Medical Journal* of April 8th, 1916, Lieutenant-Colonel T. R. Elliott and Captain Herbert Henry made some important remarks on the " After-history of both Operated and Unoperated Gastric Wounds." They showed that sutured and non-sutured wounds and contusions are subject to ulceration, secondary hæmorrhage, and perforation. Secondary hæmor-rhage occurred on the sixth, twelfth, and fifteenth days respectively ; death occurred on the ninth, twenty-sixth, and twenty-fifth days, the first from hæmorrhage and the last two from peritonitis. Colonel Elliott thinks this points to the necessity of careful feeding, and especially to the with-holding of extractives. Sub-diaphragmatic abscesses have been met with, but are not so common as might be supposed—even in the pre-operative days, according to Sir George Makins.

MORTALITY AND CAUSES OF DEATH.—The mortality in all cases where the stomach was wounded is 60·9. In cases un-complicated with wounds of other hollow viscera, the mortality is 52·7 per cent. (in the first 500 cases the mortality was 43·7 per cent.). In those complicated with lesions of other hollow organs, the mortality rises to 77·8 per cent.

The increased gravity of multiple wounds of different organs is well shown, for while the stomach has a mortality of 52·7 per cent., the small intestine of 65·9 per cent., and the great gut of 58·7 per cent., the combination of such injuries shows a mortality of 100 per cent. in this series of cases.

If all the published statistics are massed one gets 138 cases in which the stomach was wounded, with 88 deaths and 50 recoveries—a mortality of 63·7. The numbers of cases, in which the stomach was the only viscus wounded are not sufficient to furnish any reliable inference, but the deaths and recoveries are almost equal.

When the effect on the mortality of an associated wound of a solid organ is considered, the result is not so clear. Thus in 38 cases, of which 17 recovered and 21 died, we find that there were 5 cases of liver wound among the recoveries, and 5 among the deaths. Among the deaths there were also 4 cases of injury of the spleen, 1 of the pancreas and liver, 1 of the pancreas and kidney, and 1 of the pancreas. The complication of spleen injury would appear to be a grave one.

Out of 29 fatal cases uncomplicated with injuries of hollow organs, the actual cause of death in 25 cases was as follows : shock and hæmorrhage, 15 ; peritonitis, 5 ; lung trouble, 2 ; gas gangrene, 3.

Small Intestine.

FREQUENCY.—In 965 operated cases the small gut was found wounded 363 times. In 255 instances it was the only hollow viscus wounded.

ASSOCIATED WOUNDS OF OTHER ORGANS.—Stomach, 19 (5 with colon) ; colon, 89 (5 with stomach) ; rectum, 4 ; bladder, 16 ; liver, 8 (gall-bladder twice involved) ; kidney, 7 ; spleen, 3. The sites of the colon wounds were as follows : cæcum, 13 ; ascending colon, 6 ; hepatic flexure, 7 ; transverse colon, 23 ; splenic flexure, 3 ; descending colon, 13 ; pelvic colon, 18.

NATURE OF THE WOUNDS.—There does not seem to be any great difference in the frequency with which the jejunum and ileum are wounded, though perhaps the figures at my disposal are too small to draw a comparison, as the site of the lesion has

not been stated with sufficient frequency. In the case of the duodenum, one may state with accuracy that it was wounded 16 times among 363 small-gut injuries.

The injuries of the ileum would appear to be more serious than those of the jejunum. This is also supported by the fact that cases suitable for suture are more common in the upper than in the lower part—a circumstance to be expected when the size of the tube and thickness of the walls of the jejunum are compared with the smallness of the tube and the thinness of the walls of the ileum. The multiplicity of the coils in the latter also favours more extensive injury.

The character of the small-gut wounds varies in some degree with the projectile that caused them, but not to the extent that one might expect. A bullet may inflict as severe an injury as a piece of high-explosive shell. It used to be thought that a patient shot with a bullet had a better chance than one injured by a shell fragment. The present war has proved this to be a mistake. As a matter of fact, the least severe wounds are caused by the small fragments of bomb and shell.

Bullet Injuries.—The injury may be complete or incomplete; *i.e.*, it may open the lumen, or it may only score, bruise, or tear the outer coats.

The most common injuries are the perforations made by the bullet striking the intestine at right angles to its long axis. Here there are two perforations, through which the mucous membrane pouts to form a small round rosette. Some holes are so small as to hardly admit the kind of bullet that made them; through such holes the mucous membrane does not pout. As the flight of the bullet becomes more inclined to the transverse or long axis of the gut the perforations become slits, but there are still two separate wounds. These wounds gape somewhat, and the mucous membrane overlaps the cut muscular coat, so that a considerable mucous surface meets the eye. The general appearance still suggests a rosette, but with one axis longer than the other. The two slits may enlarge until the continuity of the intestine is only maintained by two narrow strands of the wall.

In other cases there is only one wound, involving different

portions of the circumference of the intestine; it may reach from near the mesenteric border to near the free margin, or involve the free margin only. In other cases the free margin is slit right back to the mesenteric border, so that only a narrow strip of wall remains. The last piece to be divided is usually the attached portion; here there is a wide gaping wound with
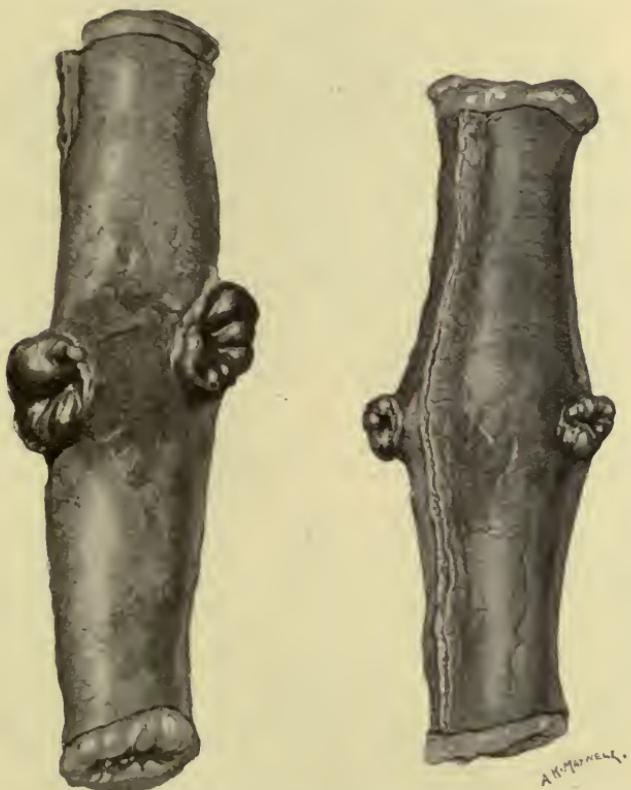
Fig. 11.—Jejunum: gunshot perforation, resected nine hours after injury. It shows the protrusion of the mucosa which usually occurs. Death. (Captain Hamilton Drummond.)

an extensive exposed mucous surface. In extreme cases the gut is completely divided. In another extreme form of injury the intestine is only represented by a long, narrow, and ragged strip of bowel.

The explanation of the transverse direction of the lesions is to be found in the looped arrangement of the small intestine, whereby the greater part of the tube lies in a vertical direction.

As a man is usually shot either from side to side or from before backwards, the missile will hit the intestine at right angles. If the bullet takes an up-and-down direction, one meets with longitudinal lesions of the gut.
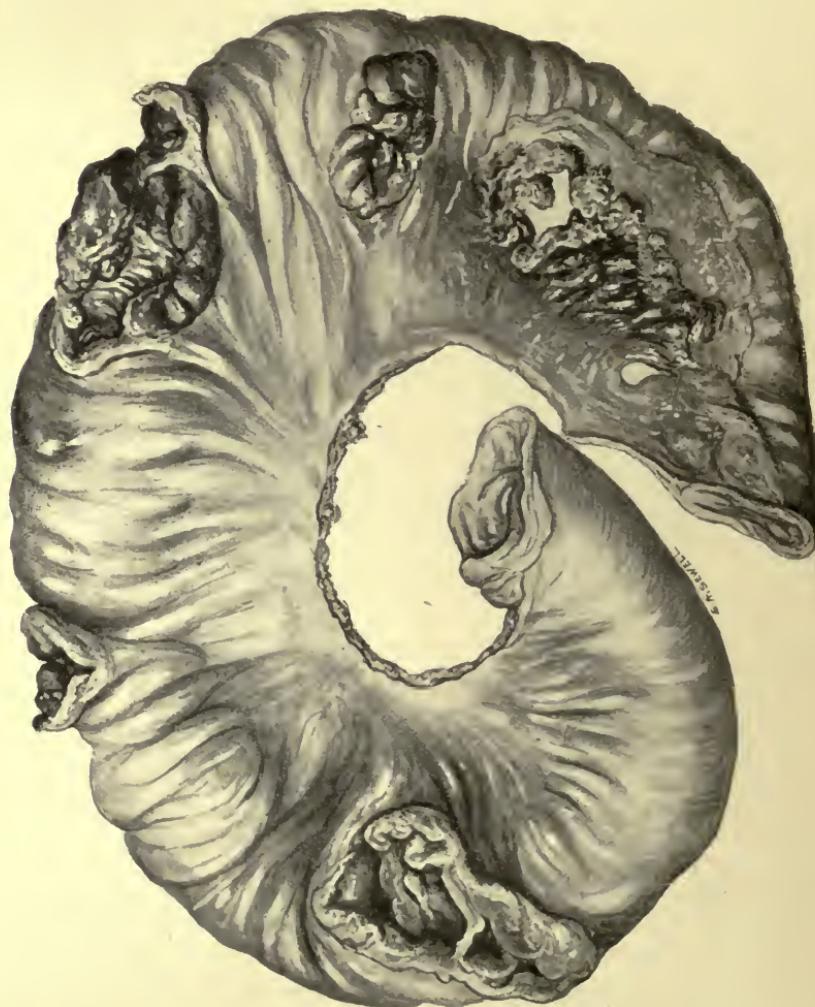
Fig. 12.—Wounds of small intestine caused by a bullet. P.M. specimen. Under care of Captain J. B. Haycraft. (*Medical Society of London* and *Brit. Journ. of Surgery.*)

In any one case all types of injury may be encountered.

Shell Fragments.—These cause wounds of all varieties, generally commensurate with their size. Perhaps the wounds are

more irregular than those caused by bullets, and the clean transverse divisions of the gut more rare.

Shrapnel Balls.—These cause ragged perforations or tears of moderate size.

Bombs.—Bomb injuries often cause small multiple wounds, which are frequently collected together over a short length of the gut. The mucous membrane very often does not pout, as the hole is so small.

A·K·MAXWELL.
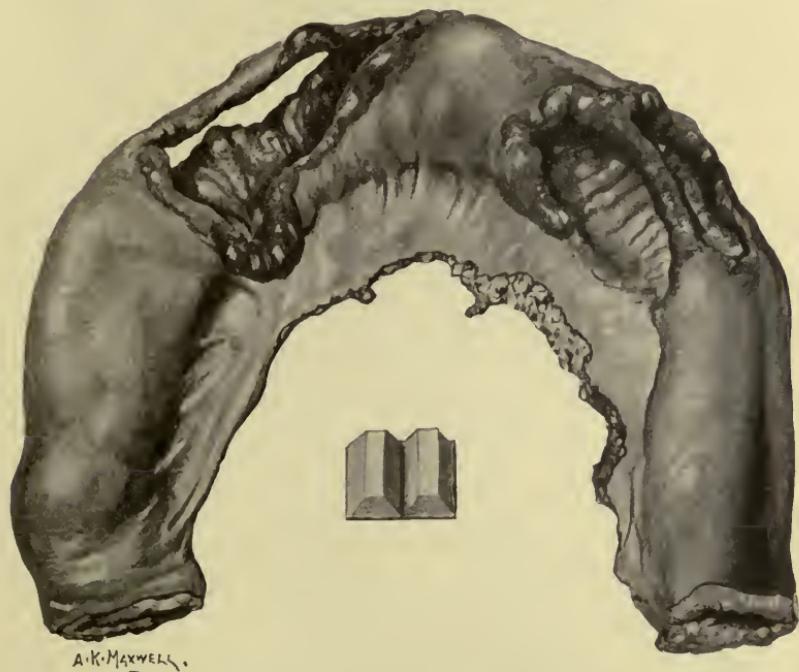
FIG. 13.—Jejunum: lacerated wounds caused by fragment of rifle grenade shown in the drawing.

Lesions of the Mesentery.—These are of all sorts and varieties, from simple perforations to irregular tears. Destruction of the mesentery may occur without a lesion of the bowel and of itself necessitate resection.

Intimate Nature of the Lesion.—The eversion of the mucous membrane is due to its redundancy, and also, apparently from an examination of microscopic sections, to a retraction of the longitudinal coat (Captain J. W. McNee and Captain J. S. Dunn). Microscopic examination of the wounded edges shows, further,

that the lesion is a very local one ; in fact, the appearance is no more remarkable than one would expect if the intestine had been cut with a pair of scissors : it usually consists of a blood infiltration in the neighbourhood of the wound. The mucous coat stains well and distinctly right up to the tear.

There is nothing to suggest " remote disturbance " or the necessity for a wide excision of tissue.

NUMBER OF INJURIES.—In 124 cases the average number of lesions was 4·8 ; in 40 cases in which resection was performed the average number was 6·8, and in 84 cases treated by suture it was 4·1. Single lesions are the exception. The greatest number of lesions was 20, and 6 feet of intestine were successfully resected by Captain Owen Richards. Captain John Fraser also successfully sutured 14 individual lesions and a hole in the bladder. The lesions are usually collected close together, but sometimes they are disposed in two or three groups which necessitate multiple resections. Occasionally they are scattered over the entire length of the small intestine with wide spacings.

The length of bowel involved may be gathered from the following figures, which represent in 25 consecutive cases the amount resected (in inches) : 30, 48, 18, 24, 30, 48, 48, 108, 30, 18, 48, 8, 20, 24, 36, 5, 48, 48, 24, 30, 48, 24, 16, 30, 24. In some of these cases, in addition, other lesions were sutured when they lay at some distance from the more severe injury.

SYMPTOMS.—There is nothing more to be added to what has been said under the heading of " Diagnosis of Intraperitoneal Damage " (see p. 51).

TREATMENT.—A long paramedian incision is the rule, except in those cases which have been dealt with when the site of the incision was discussed.

The actual operative technique in the abdomen is as follows : Any blood present must be got rid of, and the bleeding stopped. As a rule, the whole length of the small intestine must be explored, with the possible exception of those cases of side-to-side wounds involving one-half of the abdomen where a transverse incision has been used. In such cases, if there is no blood, and the whole length of the missile track can be seen, it may be possible to dispense with the routine examination.
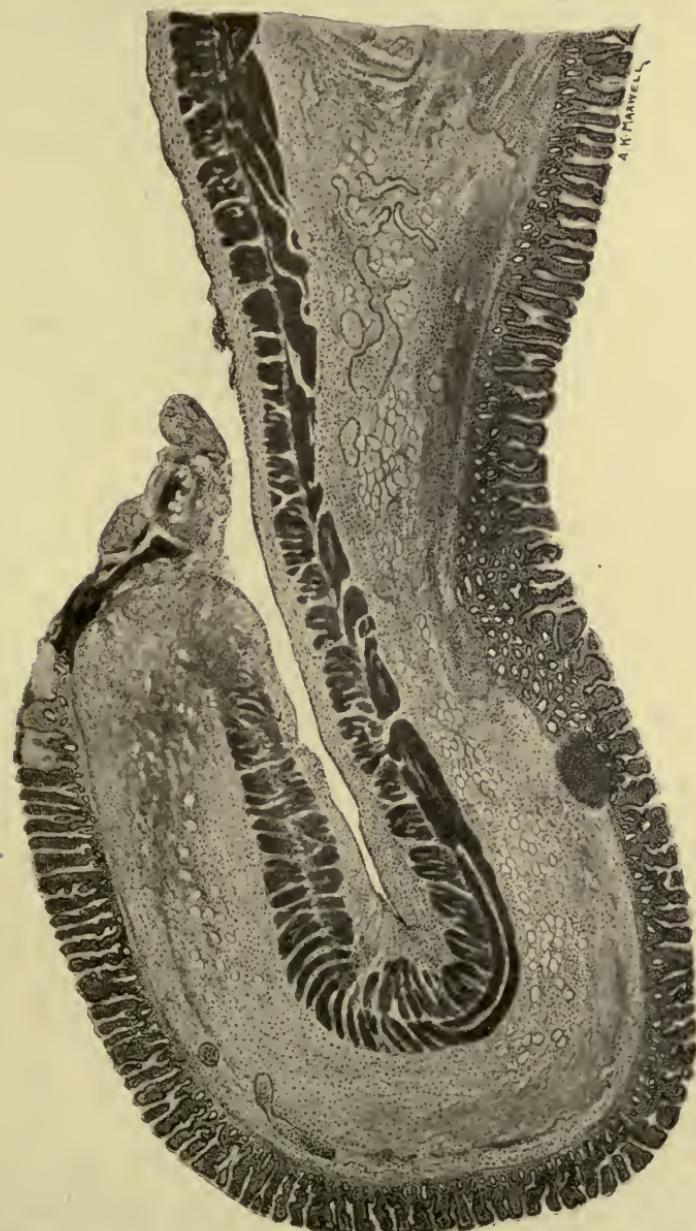
Fig. 14.—Section of wound of small gut. It shows the eversion of the edge of the lesion. The mucous membrane and other coats are, except for some blood infiltration, normal right up to the cut edge. (Specimen by McNee and Dunn.) (*Medical Society of London* and *Brit. Journ. of Surgery.*)

The cæcum or duodeno-jejunal junction is first picked up and brought out of the wound ; then the intestine is inspected,

Fig. 15.—Jejunum from the same case as Fig. 11 : thrombosis of vessels from injury to the mesentery at two points. There were twelve perforations of the small gut. Resection of 4 feet ; end-to-end union. Death. (Captain Hamilton Drummond.)

taking care to look at both sides and to replace the examined part within the abdomen. If a small hole is found, and the gut beyond it for 6 or 8 inches is intact, the hole is sewn up. If the

next lesion that is encountered is a small one, the process may be repeated. If, however, the first lesion is a large one, it is better to cover it up with gauze and a clamp, and then proceed with the examination of the whole length, for a big lesion, if quickly followed by another, may necessitate resection, and the amount to be resected can only be determined when the total injuries are known.

When the small intestine has been dealt with, the stomach is explored, if there is any likelihood of its being injured. The colon is dealt with last of all, as it is here that an artificial anus may be very likely necessary. If, however, a transverse incision has been used, it is best to deal with the great-gut lesion first, and so limit the possibility of further spreading the infection.

Suture or Resection.—Suture should be practised when possible; small discrete injuries, however numerous, should be sutured ; and it is probably best if the injuries are severe, or even complete, provided they are not too near together. It is also better to narrow the bowel than to resect, even if it involves a lateral anastomosis.

Resection should be reserved for cases where the bowel is practically destroyed, where there are several severe injuries or complete divisions close together, and where injuries extending into the mesentery, or infarction of vessels, give no choice.

The following figures show the length in inches resected in some successful cases taken in order : 36, 15, 36, 8, 8, 44, 12, 36, 9, 18, 8.

Multiple resections in this series have always been fatal, though there have been some successful cases in other series.

TABLE IX.—*To show the Results of Suture and Resection in Cases uncomplicated by Wounds of other Hollow Viscera.*

Operation.				To Base.	Died.	Mortality.
Resection	..	..	..	26	87	76·9
Suture	..	..	..	..	59	71	54·6

The greater fatality of the resection cases depends largely on the initial injury, especially on the loss of blood ; but in reading over the cases, one finds many instances of resection where the condition of the patient was at any rate fair, and yet a fatal result followed. It seems as if resection definitely increased the shock.

Circular v. *Lateral Suture.*—The old controversy is still unsettled.   Results are as follows (Table X.), the balance being in favour of lateral anastomosis, but the numbers are small :—

TABLE X.—*Circular and Lateral Suture compared.*

Operation.	To Base.	Died.
Circular enterorrhaphy	18	69
Lateral anastomosis	8	18

If a lateral suture is used, it would seem best to let the two portions of the bowel overlap well, so as to get the lateral opening in the gut a little distance away from the ends, where motility is last to return.

Technique of Suture or Resection.—A single row of stitches is practically always sufficient in suture. Care should be taken to close the rent in a transverse direction to save narrowing the lumen.

Many operators have found that a single suture line is sufficient also in resection.

Owing to the nature of the contents of the upper bowel, greater care is probably needed in suturing the jejunum than the ileum.

Primary Short-circuiting ; Enterostomy.—These operations have been done at the primary operation to relieve a dilated upper segment, or as purely prophylactic measures. They are not to be recommended, though possibly useful if the upper part of the bowel is distinctly dilated from sepsis. They have, I believe, been abandoned.

Secondary Short Circuit.—This has been done on several occasions, but with little success (one in this series).

Treatment of a Prolapsed Knuckle.—In the early days there was some difference of opinion as to what was the best treatment for this condition. Nowadays, with the establishment of the operative treatment, most probably the right thing to do is to open the abdomen and deal with the lesions which are found.

Sepsis.—To judge from the peritonitis present, it may have made considerable headway in four hours, or it may be practically absent after twenty-six hours.

Mortality and Causes of Death :—

Table XI.—*To show Increasing Mortality of Complications.*

Site of Wound.	To Base.	Died.	Mortality.
			Per cent.
Small gut	87	168	65·9
Small gut and stomach ..	4	10	}
Small gut and colon	22	63	}
Small gut and rectum	—	4	} 74·1
Small gut, stomach. and colon	—	5	}
Small gut and bladder	1	15	

Table XII.—*To show the Causes of Death in a Consecutive Series of Resections and Sutures respectively (uncomplicated).*

Cause of Death.	Resection.	Suture.
Peritonitis	14	14
Missed lesion	1	3
Shock and hæmorrhage	15	11
Gas gangrene of belly wall ..	5	4
Asthenia	1	1
Paralytic ileus	—	2
Pulmonary embolism	—	2
Pneumonia	—	1
Bronchitis	—	2
Gangrene of lung	—	1

The suture line has on very few occasions shown any fault, and where peritonitis has supervened, it must be put down to other causes.

TABLE XIII.—*To show the Average Number of Lesions in Fatal and Successful Cases respectively.*

Operation.				To Base.	Died.
Resection	..	..	..	4·1	7·1
Suture	..	..	..	3·45	4·27

The Different Parts of the Small Intestine compared.—When the comparative dangers of a wound of the duodenum, jejunum, and ileum are considered, the figures at my disposal are not very adequate, since the jejunum and ileum have not been distinguished a sufficient number of times. A wound of the duodenum is a fatal injury, as in eleven cases of wound of this viscus only two recovered. As regards the lower part of the small gut, a wound of the jejunum would appear to be the least dangerous.

High Mortality of Associated Bladder Wounds.—A wound of the bladder seems to be an extremely serious complication of the wounds of the small gut. In the present series there were sixteen instances of wounds of this viscus, and all but one died. This is due, partly at any rate, to the fact that when the bladder is injured the lesion of the small gut is generally very serious and situated in the closely coiled ileum. On the other hand, half the fatal cases complicated lesions of the small gut that were treated by suture, and presumably, therefore, were not very serious. This would tend to show that there is an inherent danger in a wound of the bladder itself. Very likely the extra time taken to deal with the lesion is a great factor in the result. In addition, there is often a fractured pelvis with these injuries.

Complicating Wounds of the Spleen.—There were three cases complicated by splenic injury, and two of them were fatal. With this exception, the solid organs do not seem to have played a great part in the mortality.

Large Intestine.

FREQUENCY.—In 965 operated cases the colon was wounded 252 times. In 155 cases it was the only part of the alimentary tract hit.

Hollow Viscera.—Table XIV. gives the number of times that the stomach and small gut suffered together with the colon.

The comparatively small number of times that the splenic flexure was injured is somewhat remarkable. It may be that the difficulty of differentiating between transverse and descending colons and splenic flexure may have something to do with this, and that some of the injuries of the two former parts should really have been described as lesions of the latter ; the observations were made, however, by a number of operators.

Table XIV.—*To show Hollow Viscera injured with Different Parts of Colon.*

Site of Wound.	Wounded with Stomach.	Wounded with Small Gut.	Alone.	Total.
Cæcum	2	13	16	31
Ascending colon ..	—	5	36	41
Hepatic flexure ..	1	7	24	32
Transverse colon ..	4	22	15	41
Splenic flexure ..	—	3	18	21
Descending colon ..	·2	9	17	28
Pelvic colon ..	—	18	23	41
Position not stated	4	12	6	22
Totals ..	13	89	155	257

(*a*) There were several cases in which two parts of the colon were wounded ; the highest wound only has been given. (*b*) There were five cases in which the stomach and small gut were both wounded along with the colon. The total colon wounds therefore number five less than the grand total given in the table.

Solid Organs.—The solid organs do not often seem to be injured at the same time as the colon. The kidney was hit seven times, the liver seven, and the spleen seven. The bladder was injured four times (for two cases of associated wounds of the bladder and rectum see " Rectum "). The ureter was injured in two cases.

Nature of Injuries.—The injuries of the large intestine are really similar to those of the small gut. The differences that are to be noted are due to (1) its larger size, (2) its absence of coils,

(3) its absence of mesentery, and (4) its proximity, in some portion of its extent, to bone.

(1) The large size of the tube leads to a preponderance of tears or perforations ; but instances are met with in which the whole lumen is completely divided, and this happens both in the fixed portion and in that endowed with the mesentery. Complete division is due to a collapsed condition of the gut, when it may be, as is well known, but little bigger than the small intestine ; the transverse, descending, and pelvic colons are the parts most frequently divided.

(2) The absence of coils means that multiple injuries are not common, and, when they occur, are not so numerous as in the small intestine. The multiple injuries are found at the bends. In one case which may be mentioned there were six perforations : two in the ascending colon, two in the hepatic flexure, and two in the transverse colon. In another case there were three wounds in the caecum and ascending colon, and two in the hepatic flexure. In a third case there were five wounds in the pelvic colon.

(3) The absence of the mesentery, over the great part of the colon, means a frequent occurrence of retroperitoneal wounds. These are difficult to find, and are largely responsible for the heavy mortality. The partially covered portion of the small intestine—namely, the duodenum—has likewise a very large mortality.

(4) The proximity to bone leads to wounds of the caeum, the two vertical colons, and the pelvic loop, by spicules of bone ; and, as has been pointed out, these injuries are apt to be overlooked, because the perforations in the peritoneum are not conspicuous.

Infarction.—This type of injury is met with in the small intestine, but I think it is rather commoner in the large. The caecum with the ileum and the descending and iliac colons have all been found in this state.

Ulceration of the Mucous Membrane associated with Rupture of the Muscle Coats.—Captains H. Drummond and J. S. Dunn have called attention to this condition.* The ulceration may occur

* *Brit. Journ. of Suegrry*, vol. v., No. 17, 1917.
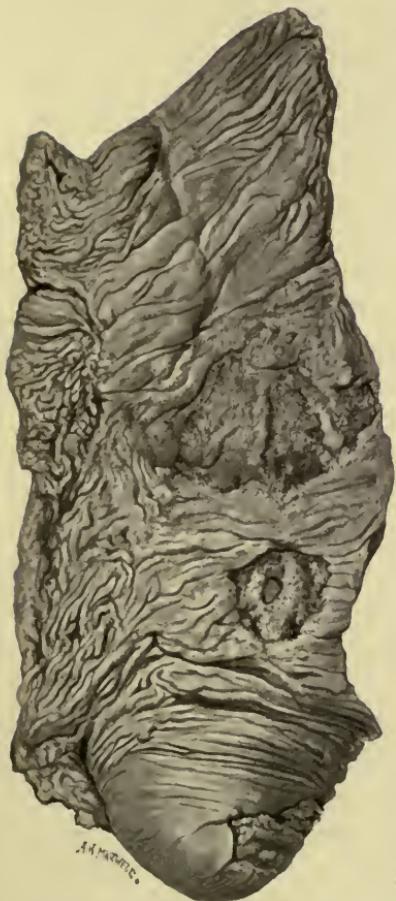
Fig. 16.—Mucous surface of caput cæcum and part of ascending colon in Case 5. There are three fairly extensive ulcers on the posterior wall, one being in the caput. The base of each ulcer is formed by the submucous layer, and is much infiltrated with blood. (*Brit. Journ. of Surgery.*)
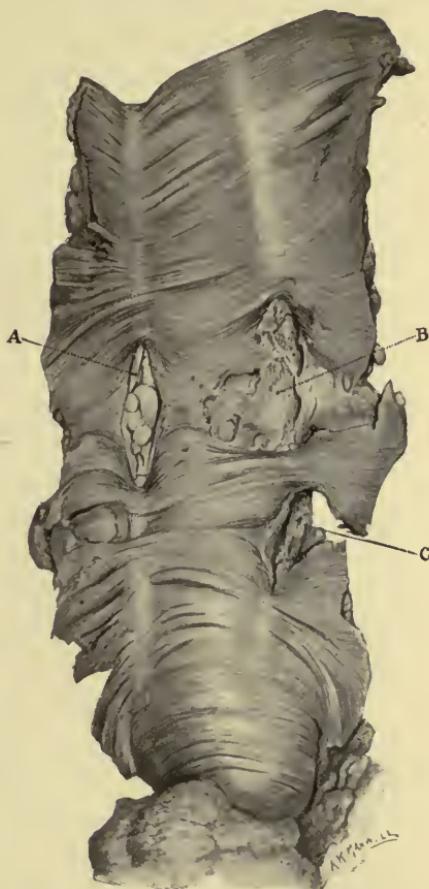
Fig. 17.—The muscular wall of the colon underlying the ulcers shown in Fig. 16. The posterior longitudinal band of muscle is torn across in two places (B and C), and the torn ends have retracted, drawing with them the fibres of the circular layer. It is seen that these lesions in the muscle correspond exactly in site with the two ulcers in the ascending colon. The tear in the outer longitudinal band, marked A, was unassociated with ulceration. The arrangement of the muscular lesions in this case affords good evidence that they were produced by indirect violence, as all of them were caused by one rifle bullet. (*Brit. Journ. of Surgery.*)

as soon as seven hours after wounding. It seems to be caused by a cutting off of the blood supply to the mucous membrane by rupture of the underlying muscle coat. It is especially interesting because the ruptured muscle may be separated from the actual track of the missile by a layer of undamaged tissue. The authors attribute the damage to a dragging effect produced by the projectile and transmitted through strands of fibrous tissue or to sudden impact on a gas-filled sac.

The rapidity with which the mucous membrane ulcerates after losing its blood supply is very remarkable.

These lesions may account for some of the fistulæ that form in the colon when it has apparently escaped injury.

One case may be quoted from the original article :—

" *Case* 5.—G. was wounded by a rifle bullet at 11.30 p.m. on June 17th, 1916, and was admitted to hospital six hours later, much collapsed. A small round entry wound was present in the left buttock, and the exit wound, which was larger and irregular, was in the right mid-axillary line at the level of the costal margin.

"Laparotomy was performed shortly after admission. There was no evidence of injury of the abdominal viscera, except some hæmorrhage on the wall of the cæcum and behind the peritoneum of the right flank. Some blood-stained urine was passed a few hours later. Death occurred twenty-one hours after wounding.

"It was found that the wound track passed from the left buttock through the sacro-sciatic notch and the upper part of the sacrum, through the belly of the right psoas muscle, and thence between the right kidney and the ascending colon. Neither of the latter viscera had been directly touched ; a layer of retroperitoneal fat a quarter of an inch in thickness intervened between the track and the colon wall. There was cellulitis and gangrene around the wound track in the retroperitoneal tissue, and films and cultures made later from this material showed abundant gas-forming, anaerobic bacilli. The capsule of the right kidney was intact, but two subcapsular lacerations were present in the cortex on the anterior aspect of the lower pole. The ascending colon exhibited externally only some hæmorrhage on its inner

side.   When this portion of bowel was opened, two large areas of ulceration were observed on the posterior wall, while a third was seen in the caput cæcum (Fig. 16).   The two uppermost ulcers lay almost directly over- the bullet track.   Each ulcer penetrated deeply into the submucous coat, but not quite through it ;   the bases were necrotic, and dark with hæmorrhage.   The mucosa and submucosa were then dissected off from the muscular layers.   By this means it was shown (Fig. 17) that underneath the middle and uppermost ulcers the posterior longitudinal band of muscle had been sharply torn across.   The torn ends were widely retracted, and the circular fibres, though not lacerated, were drawn apart with them, so as to leave a complete wide gap in the muscular layers.   Each of these lesions was associated with some hæmorrhage, and the exposed retroperitoneal tissue was foul and gangrenous.   A like muscular lesion was also observed in the outer longitudinal band, opposite the level of the upper ulcer, but it was unaccompanied by hæmorrhage or by ulceration of the mucosa.   In relation to the ulcer in the caput cæcum, there was only slight tearing of the circular fibres, with some hæmorrhage."

Escape of Contents.—The large intestine is often laden, but the condition of the contents renders massive escape less frequent than it would otherwise be ;   however, taken all in all, escape from the large intestine is more frequent than from the small, especially when the cæcum and ascending colon are involved.

Character of the Lesions in Different Parts of the Colon.

Cæcum.—There has been a fair number of cæcal wounds. Most of them have been small in extent, and have lent themselves to suture.   In other cases the wounds have been so big as to necessitate an artificial anus.   In one case there was bruising of a transposed cæcum.   In a good many cases there was a large retroperitoneal hæmorrhage ;   this injury was in one instance accompanied by acute dilatation of the sto ach.

Transverse Colon.—All kinds of wounds are met with here, from a simple single lesion to complete division.   True anteroposterior wounds are not very common, and as a rule the transverse colon is struck obliquely, the bullet passing through

the anterior part of the lumen. It has already been stated that such wounds are often accompanied by lesions of the stomach and small intestine. It was owing to this association that so few wounds of this portion of the colon arrived at the Base in the preoperative days.

The posterior surface is sometimes wounded, and this may be overlooked unless it is borne in mind that such an injury is possible, for it is not obvious unless a special search is made. Bleeding from the vessels supplying this portion of the bowel is fairly frequent.

Vertical Colons (Ascending and Descending Colon).—It is convenient to take these two portions together, as they have no mesentery. Both, and especially the descending colon, lie rather farther from the lateral line than would appear. The wound may be completely intraperitoneal or extraperitoneal, or both combined. The actual lesions are perforations, slits, tears, or complete divisions. Perforations are most commonly met with in side-to-side wounds, and complete division in antero-posterior wounds. All varieties may be complicated with small-gut injuries. At the Base, Makins noticed that wounds of the ascending colon were more common than other colon wounds ; and he attributed the frequency of the ascending colon wounds, compared with those of the descending, to the latter being more often accompanied by small-gut injuries, owing to the fact that the small gut overlies it. This explanation seems to a certain degree just. Out of forty-one wounds of the ascending colon, only five were complicated by small-gut lesions ; whereas twenty-eight wounds of the descending colon had associated small-gut injuries in nine instances. On the other hand, wounds of the ascending colon are actually more frequent than those of the descending—forty-one to twenty-eight. The comparative rarity of descending colon wounds may also be due to the fact that the descending colon lies so deep that any bullet passing from side to side and involving it would traverse a coronal plane situated so far back in the body as to involve the spine and great vessels. Again, the descending colon is usually much smaller than the ascending, so that it offers less of a mark for the missile.

The intraperitoneal wounds of the vertical colons are fairly easy to find and to deal with if a suitable incision is used. The extraperitoneal are very difficult, and most probably are more often missed than any other. The extraperitoneal wound, which may be small and valvular, is difficult to find because it lies in a mass of areolar tissue ; and the difficulty will be greatly increased when this tissue is infiltrated with blood, as it so often is.

Hepatic Flexure.—Next to the transverse colon the hepatic flexure is the easiest of all to deal with, as it lies fairly superficially. Its form leads to multiple injuries.

Splenic Flexure. — This, from its position, is the hardest of all the large intestine to deal with, and even with the best-placed incision it is difficult to examine properly without mobilisation.

Pelvic Colon.—This portion of the large intestine is anatomically more like the small intestine than any other part of the colon, and the lesions are somewhat similar. There are slits, perforations, or complete divisions ; and it is, next to the transverse colon, most often complicated with multiple small-gut injuries. Fracture of the pelvis, so often associated, increases the gravity of the case. I have been struck with the great variations in position, as shown by the different situations of the wounds of the gut in different cases in which the bullet has taken a similar direction.

SYMPTOMS.—The symptoms of intraperitoneal wounds of the large gut are similar to those of the small intestine. A great difference lies in the behaviour of the extraperitoneal wounds, where all grades of infection are met with. Sometimes we have cases of acute sepsis, with or without gas formation, which are fatal in a few hours. Such cases are often past help when they arrive. They are cold, blanched, and clammy, and the pulse is running ; in fact, their appearance often suggests acute hæmorrhage. To this class of case Captain John Fraser, M.C., has given the apt name of " colon septicæmia."

The dangerous sepsis—shown by the high mortality—of the colon anus, when formed in the vertical colons, has led some operators to always make an attempt to close the bowel. Un-

fortunately the damage is already done when the case has come under treatment. In other cases the symptoms are less acute, or are not seen when the case has arrived. Some with a small single loin wound, arriving late and left, do well even though a fæcal fistula forms. In others signs of intoxication and local infection appear, both of which may be relieved by incision, with the possible establishment of a fistulous opening. Sepsis is sometimes due to infective material carried in with the missile, and not to a communication with the bowel.

In all cases it is well to err on the side of making a good opening for drainage.

TREATMENT.—The fact that some unoperated colon cases did arrive at the Base and recover cannot now be advanced as a ground for abstention except in cases which arrive late.

Incision.—It may still be necessary to use a paramedian incision for a general exploration of the abdomen, for the exclusion of, or for dealing with, other injuries. The transverse and pelvic colons are best dealt with from such an incision, as these lesions are commonly associated with those of the small gut. It may be necessary to supplement this median incision with one toward the side of the body when either of the vertical colons is found wounded. When the missile has only traversed the loin, the horizontal incision is by far the best. The rectus sheath incision may be preferred by some for exploration of the hepatic and splenic flexures ; but the association of kidney injuries with these wounds makes a horizontal incision more expedient, as the kidney can be dealt with in the posterior extremity of the wound, whereas an attempt to remove the kidney through the anterior incision is not very convenient.

Open wounds involving the loin, and possibly involving the colon, may be dealt with by local enlargement ; but, in the absence of X-rays, a median incision, to exclude other injuries, will most probably be required.

Method of dealing with the Lesions.—This is largely determined by three factors : (*a*) the size of the tear ; (*b*) the situation of the tear ; and (*c*) the state of the patient, in whom other injuries may have been dealt with.

Cæcum.—Here it is better to suture if possible, but to provide adequate drainage if there is any possibility of an extraperitoneal wound. In wounds of the extraperitoneal part which have only been found after mobilisation of the colon, even if suture is possible, it is advisable to shut off the general peritoneal cavity by a line of sutures joining the anterior surface of the bowel to the lateral abdominal wall and provide good posterior drainage.

Transverse Colon.—The transverse colon is the most easily dealt with of all the colon lesions. When the wound is large, the question is really one of whether suture or an artificial anus is the quicker method of dealing with the case, for here probably other lesions have been dealt with, and the condition of the patient is not likely to be very good.

Vertical Colons.—Small lesions are easily closed if intraperitoneal. Wounds involving the extraperitoneal portions of the gut are dangerous, and, even if they are closed by suture, adequate external drainage must be provided. No doubt suture is the ideal method, but it is often very difficult, and in some cases impossible, owing to the loss of substance. Here the only plan is to make an artificial anus. In the retrocolic hæmatomata so often met with, it is often impossible to exclude colon injuries ; these therefore must be freely drained.

Hepatic Flexure.—The same rules apply here as to the transverse colon, the only point being that mobilisation of the flexure may be necessary to get at the lesion.

Splenic Flexure.—This is the hardest of all to manage satisfactorily, both on account of the difficulty in reaching it, and of the mobilisation necessary to find the hole. An artificial anus is often necessary.

Pelvic Colon.—This is easily dealt with in its upper portion. Care must be taken to exclude wounds on the border of the gut uncovered with mesentery. In one case a minute fragment of bomb had entered the mesentery, which was here loaded with fat, at a little distance from the bowel, and had penetrated into the bowel at the mesenteric attachment. The Trendelenburg position greatly facilitates treatment of low-lying injuries.

TABLE XV.—*Showing Colon Injuries uncomplicated with Wounds of other Hollow Viscera, the Site of the Lesion and the Treatment.*

Site of Lesion.				Sutured.	Artificial Anus.	Total.
Cæcum	..	..	..	13	3	16
Ascending colon		..	..	25	11	36
Hepatic flexure	..	..	..	16	8	24
Transverse colon		..	..	13	2	15
Splenic flexure	..	..	..	10	8	18
Descending colon		..	..	9	8	17
Pelvic colon	..	..	..	16	7	23
Position not stated		..	..	—	6	6

An interesting fact in the above table is the small number of artificial ani that it was found necessary to establish at the site of a lesion in the transverse colon when no other hollow viscus had been damaged.

Proximal Colostomy.—It seemed probable, when starting work, that proximal colostomies would have a much wider application than has been found to be the case. They are, of course, useful in limiting the amount of septic absorption in cases of wounds of the vertical colons ; but, as has been pointed out, this tissue is already infected at the time the cases come under treatment. One does not feel inclined to make an extra opening in the bowel, often at the end of a long operation. Proximal colostomy to be of any use must be complete, and it probably finds its best application in those cases of loin wounds on the left side in which sepsis develops late, and in rectal injuries. It has been used considerably at the Base for fæcal fistulæ developing from colon wounds when suture has failed to close the rent.

Of ten proximal colostomies done at the Front five were for rectal wounds and five for colon injuries distal to the transverse colon.

A transverse colostomy is to be recommended. A cæcostomy has proved of little value at the Front, but has been useful, I understand, at the Base.

MORTALITY AND CAUSES OF DEATH.—The mortality of colon

wounds, uncomplicated with other lesions of the alimentary
tube, is 58·7 per cent. ; it may be compared with that of the
small intestine, which is 65·9 per cent. The colon mortality is
greatly raised by that of the colon anus, for, whereas suture of
the colon has a mortality only just over 50 per cent., that of colon
anus is 73·5 per cent.

These figures must not be taken to mean that a colostomy is
a necessarily dangerous operation, but only that sepsis is likely
to cause death in those injuries that require a colostomy. Infec-
tion has already started where the colostomy has been performed.

It is interesting to compare the above figures with those given
by Makins in the preoperative days.

Table XVI. clearly indicates that in the preoperative period
a man with a colon wound had the better chance, and this
advantage still continues, though the margin is narrower.

TABLE XVI.—*Showing the Difference between the Mortality of
Small and Large Intestine Wounds in the Preoperative
and Operative Periods respectively.*

Site.	Preoperative Period (*Base*).	Operative Period (*Front*).
	Per cent.	Per cent.
Small intestine	86	65·9
Great intestine	38·7	58·7

No definite comparison can be made between the different
parts of the colon, as the figures are not large enough.

TABLE XVII.—*Showing Comparative Mortality of Different
Portions of the Colon (Suture and Artificial Anus).*

Site of Lesion.	To Base.	Died.
Cæcum..	8	7
Ascending colon	14	16
Hepatic flexure	8	11
Transverse colon	5	10
Splenic flexure	4	7
Descending colon	8	6
Pelvic colon	8	10

Rectum (the last 12 cm. of the Alimentary Canal).

Frequency.—In 965 operated cases, the rectum was wounded 21 times.

Associated Injuries :—

TABLE XVIII.—*A Table of Rectal Injuries.*

Viscera wounded.	To Base.	Died.	Remarks.
Rectum alone ..	7	10	Three were intraperitoneal entirely.
Rectum and small gut	—	4	All intraperitoneal, all sutured.

It is remarkable that the bladder was only wounded twice in conjunction with the rectum. The same thing is to be noted in the case of the pelvic colon, which was only wounded once in association with the bladder.

Character of the Lesions.—Wounds of the rectum can be roughly divided into three classes : (1) those that may be said to complicate wounds of the buttocks, the ischial fossæ, or the perineum ; (2) those caused by missiles that traverse the pelvic portion of the abdomen ; (3) the ulcerative lesions described by Drummond and Dunn (see p. 84). All these are likely to be accompanied by fractures of the pelvic bones, spicules of which may wound the gut.

(1) The missile may be a bullet or a small or large shell fragment. In the last case especially the external damage may be very great, and a large portion of the gluteal region torn away ; the anus and lower portion of the rectum may be completely avulsed, or the lumen opened on one side only. If the projectile is small, the sphincter may be left intact, and the lumen of the tube perforated above that muscle. The peritoneum may or may not be opened. The danger most to be feared is septic absorption, but on the whole extensive wounds of the buttocks do not do so badly now. On the other hand, there is still considerable danger of gas gangrene in the gluteus maximus.

Wounds involving the sacrum, although not opening the gut,

have proved very fatal from septic infection of the presacral areolar tissue. On the other hand, it has happened on several occasions that pieces of shell, which have been felt protruding into the rectum on its postero-lateral aspect, have been removed from rectum and recovery followed without any further surgical procedure.

(2) The partially covered rectum may be wounded extraperitoneally or intraperitoneally, or both. Missiles that cause such injuries take a side-to-side, antero-posterior, or semi-vertical direction. If side to side, the entrance and exit wounds lie on the postero-external aspect of the buttocks, and whether the missile catches the extraperitoneal or intraperitoneal surface, or both, depends on the plane traversed and the obliquity of this plane to the coronal plane of the body.

The side-to-side wounds are deceptive, leading one to think, from the posterior situation, that they have missed the bowel.

TREATMENT.—The two classes of cases require separate consideration.

(1) The treatment of injuries complicating buttock wound follows the ordinary lines of treatment of wounds in general, and consists in excising all damaged tissue. In some cases it may be possible to close the rent in the bowel or sphincter; in other cases it may be beneficial to lay open the lower end of the canal by dividing the sphincter (Makins). If the peritoneum has been opened, something may be done by shutting off the abdominal cavity by sutures. The question of colostomy must be considered, and its expediency must be determined by the difficulty or otherwise of keeping the patient clean and comfortable. It will be mostly called for in those cases in which the whole lower segment of the bowel has been carried away and the torn bowel is lying patent in the pelvis. In such cases the lumen may be closed by sutures or a purse-string ligature, which device will, at all events, tend to limit contamination of the pelvis while adhesions are forming. If a colostomy is necessary, transverse colostomy is the operation of choice, because of the ease of cleansing the opening, of fitting a belt (which will then lie on the natural line of the waist), and of subsequent closure if this is desirable.

(2) Treatment of wounds of the rectum caused by projectiles that have traversed the pelvis. There will not be, as a rule, much doubt that an exploratory coeliotomy is the correct procedure ; but if any doubt exists, as in side-to-side and semi-vertical wounds, it will be well to err on the side of operation. If the peritoneal surface has escaped, the abdomen can be closed and the wound opened up from the exterior. Anterior wounds can often be sutured, though, from their depth in the pelvis, great difficulty may be experienced. A drain down to the lesion is a wise precaution in all cases. The most difficult cases of all are those which involve the rectum at the very bottom of Douglas' pouch, as here a reliable suture is often practically impossible. It has been suggested that it might be good treatment to introduce a tube through the anus up to the site of the lesion, and to cut off the bottom of Douglas' pouch, by suturing the peritoneum over it.

The question of a colostomy must be determined by the probability or not of the suture holding.

Fortunately, associated bladder wounds are rare, but a simultaneous suprapubic cystostomy and a colostomy must be avoided if possible.

Protrusion of Omentum and Viscera.

By this is meant, not the exposure of the abdominal contents through a gap in the abdominal wall, but their prolapse through a wound, often comparatively small.

OMENTUM.—As would be expected, the omentum is most frequently seen in this connection. It appears in large or small amounts in wounds situated all over the abdomen, also in those situated in both hypochondriac regions, where it reaches the outside of the body through the interspaces or through broken ribs where one hardly would expect to see it. Sometimes in abdomino-thoracic wounds it passes into the pleura and plugs the hole in the diaphragm. There are two methods by which it is extruded : it is either (1) carried out by the projectile, or (2) driven out through the entrance or exit wound by the intra-abdominal pressure. The latter is the most common.

In one case, where a shell fragment had entered above the

Fig. 18.—Rectum showing large perforation on its anterior or vesical aspect caused by fragment of shell entering over the sacral region and lodging at the base of the prostate.

umbilicus In the mid-line and had come out in the right loin behind the lateral line of the body, the omentum was so firmly carried into the long oblique exit wound that it required consider-

able force to release it ; it was, in fact, strangulated within the abdominal wall, though none of it showed externally.

Before operation became the rule it was usual to leave omental tags to slough off, and probably this is still the best course to pursue if the cases are seen late. If seen early, it is best to treat such cases as other abdominal wounds, and explore. In several instances where this has been done the intestine has been found wounded.

STOMACH.—This has been found herniated by itself, and in association with the spleen, splenic flexure, and small intestine. In one case where it was wounded and prolapsed, it was success-fully sutured and replaced, though too much of the abdominal wall had been carried away to allow the external opening to be closed.

Protrusions of the upper viscera are accompanied by a good deal more shock than is protrusion of the small gut.

LIVER.—This organ has also been partly herniated.

SMALL INTESTINE.—Next to the omentum, the small gut is most frequently herniated, and, as in the case of the omentum, it may be carried out or expelled.   Sometimes a knuckle lying outside has been actually wounded ; in other cases the extruded part has remained intact, but there have been numerous lesions in the small gut within the abdomen.

If seen early, the ordinary rules apply, and the abdomen should be opened and the lesions repaired ; if seen later— over twenty-four hours—it is not probable that anything can be done, but still it is better perhaps to explore if the condition of the patient justifies it.   A great deal of small gut can be prolapsed without excessive shock.   A man wounded six hours previously, with the greater part of his small gut on his belly wall, had a pulse of 100, and was in very fair condition.

COLON.—The transverse colon has been herniated, and in one case the gut was tightly constricted in the wound ; as the injury was two days old, the constriction was relieved, and an aritficial anus established.

Behaviour of the Omentum in Abdominal Wounds.

Some attempt has been made to study the movements of this organ, and some observations have been made by Captains

Drummond and Fraser. Where the wounds are in the upper part of the abdomen the omentum rolls itself up into a transverse pillow. If the wounds are in the lower part it remains spread out over the intestines. Cases are operated on so quickly now that the omentum has no time to find the leak and attach itself. In the early days it was constantly found glued to the lesion, and it was not until the parts were disturbed that the contents of the upper dilated intestine escaped.

CHAPTER VI.

Wounds of Solid Alimentary Organs and Spleen.

Liver.

Frequency.—In 965 abdominal operations the liver was wounded 163 times, and 148 of these were uncomplicated. To these must be added 23 cases in which no operation was done, but in which the liver was almost certainly wounded.

Associated Wounds of other Organs.—These are shown in Table XIX. It is probable that the liver was wounded in association with other organs rather more frequently than the table shows. A liver wound is often a minor complication of a much more grave lesion, and in the pressure of work it is natural that only the more serious injury should have fixed itself in the operator's mind. But when allowance has been made for this, the small number of associated injuries is somewhat remarkable.

Nature of Injuries.—A good many cases of rupture by horse kicks have been seen (though not included in this series); but most of the wounds are caused by projectiles, sometimes aggravated by fractured ribs driven in by the missile. The wounds are of all types, from a simple perforation or an avulsion of fragments, especially of the anterior edge, to an almost complete disruption.

Table XIX.—*The Number of Times Different Organs were injured in conjunction with the Liver.*

Viscus injured with Liver.	To Base.	Died.	Result not known.
Stomach	5	6	4
,, and small gut..	—	1	—
,, small gut, and colon	—	2	—
,, and colon	—	1	—
Small gut	—	1	—
,, and colon	—	4	—
Colon	2	5	—
Kidney	3	9	2
Pancreas	—	2	—

The wounds are usually commensurate with the size of the projectile : thus bullets, and small shell and bomb fragments, make perforations or scores ; larger shell fragments cause more ragged wounds. The friable nature of the liver, as would be supposed, lends itself to tearing and fragmentation ; thus there may be radiating fissures from a central hole, crater-like exits, or pieces nearly or completely torn off. In a few cases a bullet produces the most extensive destruction (see Fig. 9). A case may be mentioned in which the whole liver was shattered

FIG. 19.—Vertical wound of liver, with missile *in situ*.

An eleven-days-old penetrating shell-wound of the liver. The point of entry was a large septic wound on the right anterior axillary fold. The thoracic wall was penetrated in the right fourth interspace in the mid-axillary line, with slight tearing of the intercostal muscles and of the parietal pleura, but with no rib damage. A large hæmothorax on the right side was found on the sixth day heavily infected with a streptococcus.

The missile has penetrated the right lobe of the liver, and is lying embedded in, and partly protruding from, the inferior surface of the organ. The centre of the wound track was filled with septic liquid material, heavily bile-stained. Outside this lies a zone of necrotic liver, the necrosis having supervened on infarction, followed by sepsis. This is separated from healthy liver by a well-developed strong capsule of inflammatory fibrous tissue. (*Brit. Journ. of Surgery.*)

by a rifle bullet, and a piece 4 inches by 3 inches lay loose in the abdomen.

The track or torn surface is at first ragged and bloody ; seen after twelve or twenty-four hours, it becomes a dirty yellow-brown ; and later it may be a vivid yellow colour, due to bilious staining.

The injury, to judge from microscopic sections, is usually limited

to the vicinity of the wound ; and in those cases where destruction of cells is found at some distance from the wound it is most probably due to an infarction phenomenon (Captain J. S. Dunn). At any rate, these infarcted areas are by no means uncommon.

The gall-bladder and the common and cystic ducts have all been wounded, but the larger bile-passages do not seem to be so often wounded as one might expect.

SYMPTOMS.—The symptoms are often slight, and one has no doubt in deciding that the right course is the " expectant " one. Sometimes the symptoms seem surprisingly severe, and I

FIG. 20.—Penetrating wound of liver caused by a fragment of shell. (*Brit. Journ. of Surgery.*)

can recall two cases of tangential wounds of the liver which could not have involved the liver deeply, and in which there was no sign of blood in the abdomen, both of which were extremely shocked, one ending fatally ; unfortunately, there was no *post-mortem*. In two other unoperated cases, men with pulses of 160 recovered.

There are the usual signs of abdominal injury.

Hæmorrhage.—This is not altogether commensurate with the size of the wound, and its amount largely depends on whether a big vein has been opened or not; if not, bleeding usually ceases spontaneously in from six to ten hours.

Secondary Hæmorrhage.—This is seen at the base as a rule. " It is always associated with sepsis. The advent of such hæmorrhage is commonly accompanied by pain, distension of the belly, rise of temperature, and acceleration of the pulse, associated with pallor, restlessness, and a rapid loss of strength. With these general symptoms a localised swelling usually develops, if the patient survives the immediate loss of blood, and this may be indistinguishable from a secondary abscess " (Makins).

Biliary Function.—An escape of bile into the abdomen is sometimes met with. In one case biliary peritonitis was found at the primary operation and ended fatally ; no hollow viscus had been wounded. Makins mentions one case in which a collection of bile in the pelvis required operation on the eighth day ; the case ended fatally. In this case the bile came from the hepatic duct. Usually the bile does not escape from the torn liver surface to any extent and need not be feared. It may, however, stain the dressings a brilliant yellow. Bile is also met with in the pleura in abdomino-thoracic wounds without any special detriment to the patient.

Jaundice of a slight and evanescent character is seen in the first few days after wounding ; it has no special significance. Seen later, it is of more serious import, as it implies sepsis. Makins says* :—

" This symptom was noted as an early sign in twelve of the thirty-seven cases. It is therefore a common sign, but it is variable in degree. In some cases it is early and deep, in others slight and evanescent, and it is usually deepest when developing in association with serious septic infection.

" The fæces retain their normal colour, and deep staining of the urine is rare. Again, in fatal cases no sign of gross mechanical biliary obstruction is met with. These features raise the question of the actual nature of the jaundice, as does also its close resemblance to the hæmolytic jaundice often accompanying the gravest forms of general toxæmia. It is, moreover, often associated with a considerable degree of fever. The sign is, of course, a classical one in the course of any case of rupture of the

* *Brit. Journ. of Surgery*, vol. iii., No. 12 (1916).

liver substance, whether due to gunshot injury or any other cause, and in all it is probably hæmolytic in origin. It is at any rate a striking fact that, in the obvious absence of serious infection, jaundice is either very slight, or, as in the great majority of cases, it is not observed."

TREATMENT.—Some cases require no operation, as there are obviously no other organs wounded, and the patient's condition is good. Many cases are operated on solely because of the possibility of injury to other organs. If such injuries could be excluded, I am inclined to think that the best results would be obtained by non-interference in the great majority of cases. When, however, the projectile is a large one, it should be removed if at all accessible. If the projectile has entered through the thorax and lodged in the liver the transpleural route will be the best; it is possible to deal with both the pleural and liver injury. If the abdomen has been traversed the case is not so clear, and most probably the standard paramedian incision is best in the first instance. A subcostal incision may at times be useful. As to the treatment of the liver itself, it is often unnecessary to do anything. In other cases packing is required ; suture has not proved very satisfactory. Ragged edges may be trimmed and any semi-detached portions of tissue removed. The big bile-passages can be dealt with on ordinary lines by suture and drainage.

MORTALITY AND CAUSES OF DEATH :—

TABLE XX.—*To show Mortality of Liver Wounds.*

Treatment.	To Base.	Died.	Not known.
Operation, complicated ..	14	26	4
,, uncomplicated ..	72	32	—
No operation (no indication) ..	23	—	—

The mortality of the uncomplicated wounds is therefore 29·18 per cent.

The causes of death at the front may be seen in the following list, which shows the clinical cause of death in a series of consecutive cases : jaundice and sepsis, 1 ; shock and

hæmorrhage, 9 ; " biliary " peritonitis, 1 ; lung trouble, 4 ; gas gangrene, 1.

Speaking of causes of death at the Base Makins says that in twenty-five cases in which a liver wound was the principal cause of death 60 per cent. of the cases died of sepsis and 40 per cent. of secondary hæmorrhage. Death in a certain number was also in part due to infection of the pleura.

In uncomplicated wounds, the mortality has a distinct relation with the amount of injury, both because of the quantity of blood lost and on account of the amount of injured substance. No connection has been traced between the direction of the projectile and the fatality ; side-to-side lesions were said to be commoner at the Base. Injuries of the big bile-passages do not seem to increase the gravity to any appreciable extent.

Pancreas.

FREQUENCY.—In 965 operated cases, the pancreas was wounded 5 times. Very few of such injuries have been noted. Possibly many are missed, and diagnosed as retroperitoneal hæmatoma. In addition, many may be rapidly fatal ; the association of the gland with the big vessels need hardly be mentioned.

ASSOCIATED INJURIES.—The organ was found wounded three times with other viscera—namely, stomach, stomach and liver, and stomach and kidney. All three were fatal. It was wounded alone on two occasions, one of which went to the Base without symptoms.

SYMPTOMS.—There are no distinctive symptoms ; the lesions are found at explorations, and are sometimes accompanied by fat necrosis.

PROGNOSIS.—One case was sent to the Base in which the pancreas was obviously perforated by a bullet ; the other cases were fatal.

Makins has published some cases of wounds of this organ which he has seen at the Base. He says that they were discovered during the performance of operations for intestinal injuries, and that the typical results of the escape of the pancreatic juice have been observed. They have usually proved

fatal. He mentions one interesting case in which an abscess
formed and was opened, in which the patient eventually
recovered and was discharged to England. The man walked
six miles after his wound. He had been detained at a Casualty
Clearing Station on suspicion of an injury to the alimentary
tract.

Spleen.

FREQUENCY.—In 965 abdominal operations, the spleen was
found wounded 54 times. In 32 instances it was the only organ
damaged.

ASSOCIATED INJURIES :—

TABLE XXI.—*Showing the Complicating Injuries of the Spleen.*

Other Viscera wounded.				To Base.	Died.
Stomach	..	..	..	1	3
,, and colon		..	..	—	1
Small gut	..	..	..	—	1
,, and colon		..	..	—	1
,, ,, kidney		..	..	1	—
Colon	..	..	..	—	3
,, and kidney ..		..	..	—	2
Kidney	..	..	..	7	2

NATURE OF INJURIES.—These consist of perforations, tears,
slits in the capsule, avulsion of poles, hemisection, division of
pedicle, and almost complete disruption.

SYMPTOMS.—The symptoms are mainly those of hæmorrhage,
and the diagnosis is made on these and on the position of the
wound. Very often the organ is only found wounded in the
course of an exploratory operation. There is nothing special
about the hæmorrhage, and the damming up of blood in the left
loin, which has been said to be a feature of this injury in civil
practice, has not been conspicuous in the present campaign.
The amount of hæmorrhage varies very much, and depends
mainly upon whether the vessels are injured. The splenic
pulp has been found bleeding forty-eight hours after injury,
but usually ceases after ten hours.

Treatment :—

Table XXII.—*To show Treatment of Splenic Wounds.*

Association with other Wounds.	Packed, sutured, or left alone.		Excised.	
	To Base.	Died.	To Base.	Died.
With other organs	6	8	3	5
Spleen alone wounded ..	12	4	4	12
Total	18	12	7	17

There were five cases in which the spleen and kidney were both excised ; two of these were fatal. The other three fatal cases of excision in complicated wounds were instances of wounds of stomach. and spleen (1), and colon and spleen (2).

The spleen is often found wounded after the standard para-median exploration, and can be dealt with through this, though not very conveniently. A rectus sheath incision with a trans-verse extension or a subcostal one are perhaps more convenient. If associated with a thoracic wound which requires attention, it can be dealt with through the diaphragm by extending the rib incision to or through the costal margin. If, however, the missile has passed across the abdomen, this incision will not suffice, though the cardiac part of the stomach and the splenic flexure of the colon can be dealt with. As a matter of fact, the association of splenic and gastric injuries is not common.

If the hæmorrhage has ceased, the organ is best left alone. Suturing or packing will control the hæmorrhage if this is going on. As a matter of fact, sutured holes are apt to bleed almost as much as a raw surface, unless the hæmorrhage is fairly free. Excision should only be resorted to if the organ is badly injured or the vessels are torn.

One point has to be borne in mind in operating on these cases, especially if associated with wounds of the kidney vessels. The

hæmorrhage, which very likely has been controlled or diminished by the clotting, is likely to restart in an alarming manner directly the clot is disturbed. It is therefore absolutely necessary to have everything ready for the arrest of hæmorrhage.

FIG. 21.—Bullet wound of spleen. The organ was almost completely divided. The vessels ruptured in the hilum. Under care of Captain Owen Richards. (*Brit. Journ. of Surgery* and *Medical Society of London.*)

MORTALITY AND CAUSES OF DEATH.—Shock and hæmorrhage are the main causes of death. The mortality in uncomplicated cases was 50 per cent. One curious case may be quoted, that of a simple perforation of the spleen, where death occurred suddenly without cause on the fifth day.

CHAPTER VII.

Genito-urinary Organs.

Kidney.

Frequency.—This organ was wounded 73 times in 965 abdominal injuries. It was the only viscus wounded in 37 instances.

Associated Injuries.—The following table shows the number of times each complicating organ was hit :—

Table XXIII.—*Kidney Wounds complicated with Wounds of other Organs.*

Other Viscera wounded.	To Base.	Died.	Result not known.
Stomach ..	1	3	—
Small gut	4	3	—
Colon ..	3	4	—
Pancreas	—	1	—
Liver	3	9	2
Spleen ..	8	4	—

Nature of Lesions.—In two cases both kidneys were hit by the same missile. Both were fatal ; one had paraplegia. The nature of the projectile has no particular effect on the injury. As is the case with other solid organs, the kidney is liable to extensive rupture. The actual lesions may be perforations, scores, furrows, cracks in the capsule, avulsion or pulping of the poles, hemisection, and almost complete disruption.

Sometimes the kidney is found lying loose, the pedicle having been ruptured ; sometimes the pelvis is alone perforated ; at other times the vessels are completely divided, the ureter remaining intact. The amount of hæmorrhage depends upon whether a vessel has been injured or not ; there is very often a consider-

able perinephric hæmatoma. In contradistinction to civil injuries, intraperitoneal hæmorrhage is very frequent.

Microscopic examination shows that the destruction of kidney cells is limited to the immediate vicinity of the wound or of the fissures that extend from it. Infarction phenomena are not rare (see Fig. 23), and in some instances considerable portions of the kidney necrose if the artery supplying such part is divided outside the organ. The reader is referred to
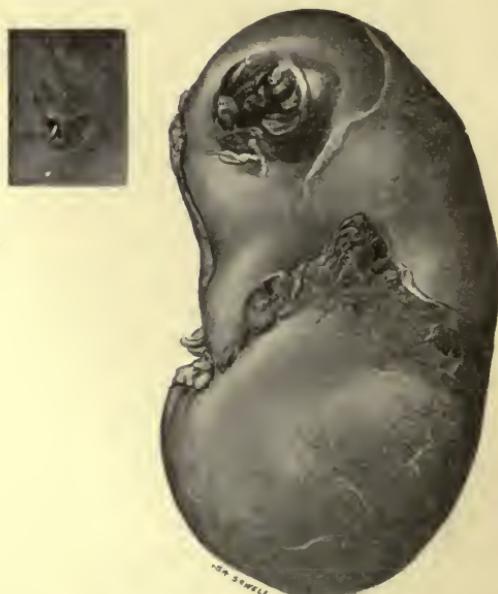
FIG. 22.—Bullet wound of the kidney.

The small aperture of entry is seen in the inset. The larger exit wound at the opposite surface exhibits well the protrusion of the renal tissue and a moderate degree of destruction. The lacerated capsule has receded some distance on the surface of the organ. (*Brit. Journ. of Surgery.*)

papers on these subjects by Captain Bashford and Colonel A. Fullerton.*

SYMPTOMS.—The shock is not as a rule very great, and depends largely on the amount of blood lost ; this, perhaps, is peculiar, when one remembers the effect produced by the kidney blow in boxing. On the other hand, one sees cases of kidney injury which recover without operation, in which the pulse

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* *Brit. Journ. of Surgery*, vol. iv., No. 15, and vol. v., No. 18.

may be as high as 140 and the shock extreme. The dulness due to free fluid in the abdomen is more common than in civil injuries, and manifests itself in the right or left side according to the organ injured.

Hæmaturia.—This is usually present, but it may not occur at once. The absence of this sign is due either to suppression, or to the presence of clots or pieces of kidney in the ureter. Profuse

Fig. 23.—Oblique perforation of the kidney caused by a bullet. The glass rod projects from the exit aperture. (*Brit. Journ. of Surgery.*)

hæmorrhage into the bladder is not common in the early stages. Hæmaturia usually clears up in a few days, but may persist.

Extravasation of Urine.—This is not usually marked, and is most probably limited to those cases in which the pelvis is involved.

Gas Infection.—This has occurred in the perinephric hæmatoma in a certain number of cases.

Excretion of Urine.—The escape of urine through the loin wound is often delayed. This may be due, like the absence of hæmaturia, to suppression, or blocking of the duct. In two

cases of double wound no urine was passed into the bladder, though it is doubtful whether there was not some from the loin wounds.   Anyhow the double wound seriously interfered with this function.   It is possible, therefore, that if only one kidney is wounded, it ceases secreting.

I asked Captain Sampson, who had a rather extensive experience with these injuries, to measure the urine after the excision of the kidney ; the amount was about 25 oz. in the day.

Fig. 24.—Bullet wound of the right kidney. This has practically bisected the organ, extending into the renal pelvis. Hæmaturia was a marked feature of the symptoms. (*Brit. Journ. of Surgery.*)

The patients were not thirsty, and did not demand water ; but if they were put on a forced hydropathy, the remaining kidney at once responded, and passed up to 80 or 90 oz.

SECONDARY COMPLICATIONS.—A secondary hæmorrhage is a fairly frequent, and often fatal, late complication.   It occurs most often during the second and third weeks after injury.   The urine is generally contaminated.   Secondary hæmorrhage may start afresh, or it may manifest itself as an exacerbation

of a persistent primary hæmorrhage. Unlike primary hæmorrhage, it is often accompanied with clotting of the blood in the bladder.

An interesting case reported by Makins * may be quoted here :—

"*Case* 2.—(Under the care of Captain Buxton.)

"A man was wounded by a bullet which entered just below the right costal margin in the nipple line, and emerged below the

Fig. 25.—Comminution of the upper half of the kidney. The organ has been reconstructed by assembling a number of fragments enclosed in blood clot. (*Brit. Journ. of Surgery.*)

twelfth rib behind. Primary hæmaturia followed, and continued, except for one day's interval, until the patient's arrival at the General Hospital on the eighth day. Some dysuria from the presence of blood clot in the bladder had necessitated occasional catheterisation.

"On the ninth day the patient's general condition was good ; he looked sallow, but the pulse was of fair strength and not rapid. The hæmaturia and dysuria persisted, and on this and

* *Brit. Journ. of Surgery*, vol. iii., No. 12 (1916).

the following day 90 ounces of urine and blood were voided, the urine containing streptococci.

"On the twelfth day, as no improvement had taken place, a type right lumbar nephrectomy was performed. The perirenal tissues were infiltrated with blood and some urine, but no extensive extravasation of urine had occurred. The bladder was full of blood clot, which was removed with a lithotrity evacuator.
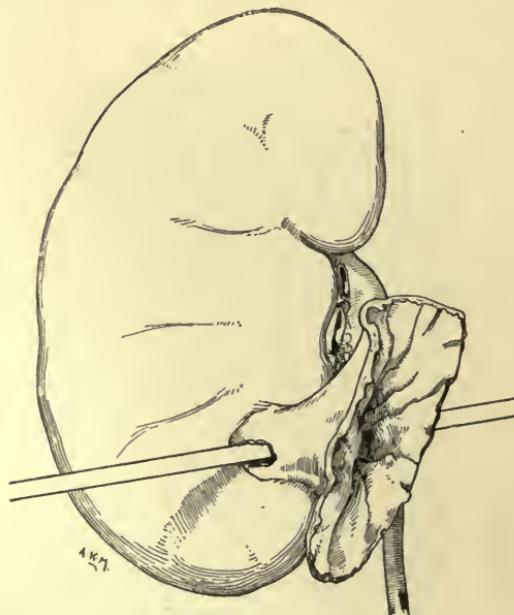
FIG. 26.—Minimal injury to the right kidney accompanying a retroperitoneal perforation of the duodenum. A second exactly similar injury was also met with. In neither case was any sign of the renal lesion observed, and in both the injured duodenum contracted adhesions to the groove in the kidney. (*Brit. Journ. of Surgery.*)

The kidney was practically bisected, and was large, probably partly as a result of infection.

"For the next three days seven pints of urine were voided daily, the quantity then decreasing until the normal was reached on the seventh day.

"The patient meanwhile was ill from the streptococcic infection, and made a very slow recovery."

TREATMENT.—The method of treatment adopted in the cases enumerated under " Kidney explored " (Table XXIV.) was packing, suture, or nothing, the actual procedure depending on

whether the organ was bleeding or not. A loin drain was used in many cases. In a large number of instances it is probable that the cases would have recovered without operation, which had to be undertaken to exclude other injury. Nephrectomy should be reserved for those cases in which the vessels are torn or the organ is greatly shattered. If a pole is shattered a local trimming of the devitalised tissue is worthy of trial.

If the kidney is probably the only organ wounded, or if the missile track only crosses one side of the abdomen in a horizontal direction, the transverse incision is the best.

TABLE XXIV.—*Table of Operations to show Treatment and Results.*

Operation.	To Base.	Died.
Kidney explored *	25	7
Nephrectomy (uncomplicated) ..	2	3
,, (spleen wounded) ..	3	—
,, (liver wounded) ..	1	1
,, (bladder wounded) ..	—	1
,, (colon wounded) ..	—	1
,, and splenectomy ..	3	2

* In these cases the kidney was considered the principal wound, and so the operation is entered under this head ; the kidney was found wounded in many other cases in the course of an abdominal exploration, but these cases are not shown in this table. The organ was wounded seventy-three times, and the difference between this number and the number (forty-nine) shown in this table represents the number of times that the kidney wound was a secondary consideration.

As was stated in speaking of splenic injuries, the hæmorrhage from wounded kidney vessels is very liable to restart with alarming rapidity directly the clots are disturbed. It is rather interesting here to mention that the number of kidney wounds treated at an advanced operating centre seems to be larger than in the Casualty Clearing Station. This is most probably due to the fact that the cases arriving earlier have not suffered so much from hæmorrhage.

MORTALITY AND CAUSES OF DEATH.—In thirty-seven uncom-

plicated cases, there were ten deaths. Shock and hæmorrhage are by far the most common causes at the Front. Associated wounds of the liver and kidney seem to constitute a very dangerous combination. At the Base, secondary hæmorrhage and sepsis play the chief part in the fatal result.

Ureter.

The ureter is not very frequently injured, but the cases have done well. The injury was found in the course of an exploratory cœliotomy. Suture or drainage formed the methods of treatment.

Colonel Andrew Fullerton, speaking of the experience at the Base, says that the urinary fistulæ resulting from wounds of the ureter heal well if left alone.

Bladder.

FREQUENCY.—This organ was perforated forty-five times in 965 operated cases. In twenty-five instances it was the only organ injured.

ASSOCIATED INJURIES.—The small intestine is the organ most frequently wounded in association. It is remarkable how seldom the pelvic colon or rectum is perforated at the same time. The pelvis is fractured in a large proportion of cases.

TABLE XXV.—*Table of Bladder Wounds.*

Association with other Wounds.	To Base.	Died.	Result not known.
Small gut (resection), intraperitoneal ..	—	5	—
,, (suture), one extraperitoneal	1	6	—
,, (resection), colon anus ..	—	1	—
,, * ,, rectum (suture)	—	1	—
Colon *	—	2	1
Rectum, extraperitoneal	—	1	—
Bladder alone injured{extraperitoneal	9	11	—
{intraperitoneal	2	3	—
Total	12	30	1

* Transverse colon, 1 ; pelvic colon, 1 ; wound of bladder extraperitoneal, 1.

NATURE OF INJURIES.—These may be either intraperitoneal or extraperitoneal, or both. The intraperitoneal lesions—perforations, tears, or slits—are very often not extensive. The extraperitoneal wounds, often accompanied by much hæmatoma, are slits or tears. They are usually situated at the sides of the bladder, and are often caused by bony spicules. There is only one instance in this series where the rectal surface was wounded. It is also remarkable how few have been the observed cases of prostatic wounds, so few that there is really nothing to be said about them. The combined intraperitoneal and extraperitoneal injuries are usually caused by oblique wounds, the missiles entering by the lower lateral part of the bladder and passing out through the peritoneal surface. Projectiles sometimes lodge within the bladder, and cause pain at a later period. Bone spicules have also been formed in the viscus. One interesting case was under the care of Captain Luker in which a projectile, passing in by the buttock, wounded the postero-external angle. It pushed a piece of cloth into the viscus and then passed on and lodged behind the pubis.

SYMPTOMS.—These are not of great importance, as most cases are submitted to operation on principle. Intraperitoneal wounds are found in the case of an abdominal exploration. The extraperitoneal wounds may be accompanied by obvious swelling above Poupart's ligament, but this sign may be absent.

There may be hæmaturia, or micturition may be impossible. Hæmaturia also occurs with bruising of the bladder without penetration. The cystoscope has not been used, and perhaps would not be of much use in the intraperitoneal wounds, as the bladder cannot be distended.

Vomiting is not an infrequent symptom in extraperitoneal wounds, and has occurred in simple extravesical hæmatoma. It is of no great value as a symptom. Extraperitoneal wounds are often accompanied with severe constitutional disturbance, the pulse mounting to 120. This phenomenon is apparently septic in origin.

TREATMENT.—*Intraperitoneal Wounds.*—These are, as a rule, easily sutured, except those which occur at the very bottom of Douglas' pouch. The bladder should be explored for a foreign

body. Suprapubic drainage is not necessary here. Catheterisation for a few days may be necessary, or a catheter may be tied in, though this treatment is not to be continued for long, and is not favoured by some.

Extraperitoneal Wounds.—These are treated by an incision down to the wound in the bladder, which latter may be sutured if possible, and a drain left in the space formed by the operation. If the wound in the bladder cannot be sutured, it is most probable that a drain down to the wound will be sufficient ; if there is any doubt, a drain into the bladder through the wound is probably the safest course. It occasionally happens that one meets with urinary extravasation in an extravesical hæmatoma and cannot find the hole into the viscus. Under these conditions it is somewhat doubtful whether the right course is to be content with an extravesical drain or to do a suprapubic cystostomy in addition. I am rather inclined myself to advocate the latter, as I have seen bad results follow such extravasation.

In those cases where the bladder is wounded on the rectal surface it would appear well to open the bladder and suture the rent from the inside, as has been done by Captain Hamilton Drummond.

MORTALITY AND CAUSES OF DEATH.—The uncomplicated bladder wounds show a mortality of 56 per cent., fourteen deaths in twenty-five cases. Shock and hæmorrhage form the causes in the majority. Fracture of the pelvis seems to greatly increas the shock, and wounds of the pelvic veins are responsible for a great deal of the hæmorrhage.

In the case of complicating small-gut injuries, the picture is dismal in the extreme. There were sixteen instances with only one recovery. Most of these cases are intraperitoneal wounds, which in civil practice, and uncomplicated, are not greatly feared. It would appear that the increase in time necessary to repair the bladder, after other serious injuries have been dealt with, was able to turn the balance against the patient, for the mortality is much worse than in intestinal injuries alone.

CHAPTER VIII.

Abdomino-thoracic Wounds and Diaphragmatic Herniæ.

Abdomino-thoracic Wounds.

A GOOD deal has been written about these wounds, and there is perhaps an inclination to regard them as a type apart and as possessing peculiar properties. It has been shown that the mortality of wounds increases in proportion to their multiplicity; it is not therefore to be wondered at that abdomino-thoracic wounds should have a heavier mortality than either chest or abdominal wounds alone. It will be seen later on that in a series of cases the total operative abdominal mortality (excluding abdomino-thoracic wounds) was 49 per cent., while that of abdomino-thoracic wounds was 55·5 per cent. This is not such a large increase when it is remembered that chest wounds within the period before evacuation to the Base produce a mortality of about 22 per cent. in themselves. Another point to be borne in mind in considering the increased mortality supposedly due to the thoracic complication is that such thoracic wounds are accompanied by wounds in a region of the abdomen that has been shown (see Fig. 4) to be especially dangerous to life.

Frequency.—In 839 cases of abdominal wounds there were 101 cases in which the missile penetrated the thoracic in addition to the abdominal cavity. The percentage of wounds involving both cavities is therefore about 12 per cent. If only operated cases are taken into account the ratio is 550 to 70, or, again, about 12 per cent.

Side.—These wounds are mostly confined to one side of the diaphragm, though the opposite chest may be involved. Wounds low enough to involve both sides of the diaphragm have usually been fatal, though some reach hospital. In this series both sides are equally affected and show an equal mortality.

Nature of Projectiles.—As in all abdominal wounds, shell fragments are the most frequent causal agents.

TABLE XXVI.

——	To Base.	Died.
Bullet	2	3
High-explosive fragments	23	47
Shrapnel ball	5	4
Grenade	2	1
Aerial bomb	—	1
Bayonet	2	1

Diaphragmatic Lesions.—These are mostly found on the sloping muscular portion. A large proportion involve only that part which is in contact with the thoracic wall. The following figures, taken in a consecutive series of cases, show the extent and form of the rent as described by the operator :—

Linear tear (in inches), 3, $1\frac{1}{2}$, 1, $1\frac{1}{2}$, 1, 1, 1, $\frac{1}{2}$, $\frac{1}{2}$, 1, $\frac{1}{2}$, $\frac{1}{2}$, $\frac{1}{2}$, $\frac{1}{2}$, $\frac{1}{2}$, $\frac{1}{2}$, $\frac{1}{2}$.

Irregular hole, size of, 5s., 1s., 6d., 2s. 6d., 2s. 6d. ; (in inches), $1\frac{1}{2}$, 2 × 1, $2\frac{1}{2}$ × 1, 2, $\frac{1}{2}$, 1, $1\frac{1}{2}$, $\frac{3}{4}$, small, small.

Puncture, described thus in ten cases.

The nature and extent of the lesion depend on the size of the missile and on its inclination to the plane of the diaphragm at the point of impact. Small missiles may make large tears if their course lies in the plane of the organ. Fractured ribs are also responsible for a certain amount of damage.

Organs herniated.—In a certain number of cases on the left side some of the abdominal viscera pass through the gaps. There was herniation in eight cases in the above series, which were mostly explored in the first instance through the abdomen. According to some observers, this number of herniations is below the average. The omentum is the organ most often involved, and the first part to pass through is the left side or the gastro-splenic fold. It nearly always accompanies other organs when they are protruded. In one unoperated case that died from other injuries about a week after wounding, the omentum protruded through the rent, effectually plugging it, and formed

the same granular-looking, mushroom-like button that one used to see on the abdominal wall in the preoperative days. As in other cases, it is both carried out or expelled by abdominal pressure. The spleen, stomach, and left part of the transverse colon are the organs next most frequently herniated. The following combinations occur : stomach and spleen ; stomach and transverse colon ; stomach, transverse colon, and small gut. The stomach does not in the early stage pass through unless the rent is of considerable size, but is at a later period herniated through a comparatively small rent.

Abdominal Organs wounded.—This is an important subject because, as will be pointed out later, it has a direct bearing on the treatment to be adopted and the route employed. Hollow viscera were wounded 28 times in 70 cases.

TABLE XXVII.—*To show Abdominal Viscera wounded in Abdomino-thoracic Injuries.*

Organ wounded.	To Base.	Died.
Stomach	—	4
,, and liver	1	1
,, ,, spleen	—	2
,, ,, transverse colon	—	1
,, ,, jejunum and spleen	—	1
,, ,, kidney	1	—
Jejunum	1	1
,, and liver	—	1
,, ,, kidney	—	1
,, ,, spleen and colon	—	1
,, ,, transverse colon	—	2
Colon	3	1
,, and spleen	—	2
,, ,, liver	1	2
,, ,, ,, and œsophagus	—	1
Liver	10	7
,, and kidney	3	3
Kidney..	2	1
Spleen ..	6	5
,, and kidney	—	1
Pancreas and splenic vein	—	1
No viscus	3	—
Total	31	39

TABLE XXVIII.—*To show the Number of Times Individual Organs were wounded.*

Organ.	Frequency.
Liver	30
Spleen	18
Colon	13
Kidney	13
Stomach	11
Jejunum	6
Œsophagus	1
Pancreas	1
No viscus	3

TABLE XXIX.—*To show Influence of a Wound of a Hollow Viscus on the Mortality.*

———	Base.	Died.
Hollow viscera wounded	7	21
No hollow viscera wounded	24	18
Total	31	39

TREATMENT.—In all cases it is very necessary to know the track of the projectile and where it has lodged. If the wound only involves the neighbourhood of the diaphragm there is no need for a complete abdominal exploration. A transpleural incision will here allow of repair to the thoracic region, and an extension of it will very likely be a convenient way of treating the abdominal viscera. If the projectile has passed farther afield it is obvious that an enlargement of the transpleural incision will not suffice, and that a separate cœliotomy will be necessary. It is in these cases that one has to determine whether the thoracic wound requires operative treatment and, if it does, whether preference should be given to it or the abdominal wound.

In making up one's mind certain facts have to be considered.

(1) It has been shown that the mortality is still largely dependent on the abdominal injury. (Table XXIX.)

(2) The chief indications for immediate operative treatment of a thoracic wound that have been advanced are as follows : (a) an open " blowing wound " ; (b) a " stove-in " chest wall ; (c) the retention in the thorax of a large missile ; (d) a wound of the diaphragm.

(a) and (b) Under these conditions the chest injury will demand to be first dealt with.

(c) In an abdomino-thoracic wound the missile will have usually passed out of the chest.

(d) Suture of the diaphragm is advocated for the following reasons : (1) to render respiration more easy ; (2) to retain the blood in the pleura and thus assist the arrest of hæmorrhage from the lung ; (3) to prevent or reduce herniation.

(1) It is still doubtful how far a wound paralyses the diaphragm or if suture will restore function.

(2) It is unsettled if pressure by effused blood is a potent cause of arrest of hæmorrhage.

(3) It is impossible to gauge the size of the hole in the diaphragm; the average size can be seen above. Large herniation does not seem to be the rule, and small ones of the omentum are not an immediate danger to life.

Although suture of the diaphragm is the ideal treatment, the universal acceptance of the transpleural route for its accomplishment as a primary measure would seem in many cases to involve a lengthening of the operation which may be prejudicial to the wounded man.

It would, therefore, seem reasonable to advance the following recommendations :—

(1) That many small thoracic wounds may be disregarded ;

(2) That when there is an open " blowing wound," or respiratory distress, or if the hypochondrium is alone involved, the lung condition should first be attended to and the transpleural route used to treat the abdominal lesion if possible.

(3) In other cases the abdominal exploration should come first and the lung and diaphragmatic lesions be attended to, if advisable, and time permits.

Mortality and Causes of Death :—

Total cases	101
Operated and evacuated	31
Operated and died	39
Unoperated and evacuated ..	7
Unoperated and died	24

In this series neither suture of the diaphragm nor the transpleural route as a primary measure was pushed.

TABLE XXX.—*To show the Influence of Abdomino-thoracic Wounds on the Total Mortality.*

—	All Cases.	Abdomino-thoracic.	Excluding Abdomino-thoracic.
Mortality, including moribunds	59·5	63·0	59·2
Mortality, excluding moribunds	49·2	50·6	48·9
Mortality, operative	51·4	55·5	50·9

Diaphragmatic Herniæ.

Considering the number of times the diaphragm must have been injured, the number of cases that have come to light is small.

Putting aside those herniæ (immediate) that are found at the primary operation there are others that occur later. They may be divided into two classes, namely those that occur within a short time (intermediate) and those that come to light after a lapse of time (remote).

The intermediate variety has usually been found within ten days or so of the wound, when an abdominal operation has been called for on account of obscure symptoms or at a *post-mortem* examination. The remote form has been found under similar conditions up to twenty-four months after the wound.

In the intermediate variety the abdominal viscera pass

through when the rent is made or soon after. In the remote form the herniation takes place at a later period.

Morbid Anatomy.—The cases have all been left-sided. The track of the missile has often been across both chests from side to side. In the intermediate form the rent in the diaphragm is large, often irregular. In the remote form it is often much smaller, although there is considerable herniation of viscera. In the recent state the edges are soft and irregular, but later on become well defined and somewhat unyielding. The shape, whatever it was at first, becomes lenticular or ovoid ; the prolapsed viscera tend to dilate and round off the irregularities. As a rule there is no sac, but this has been described in one case and may have been due to an incomplete division of the diaphragm.

There may be many adhesions or none. If present they are usually found at the hiatus, where there may be a few points of adherence or a complete marginal attachment. The omentum is mostly concerned. Within the pleura there are not usually many adhesions.

The amount of lung collapse is very various. Often there is a good negative pressure in the thorax in the remote variety.

Organs herniated.—These are the same as in the immediate form, and the omentum again is most often found to have passed through the hole. Of the hollow viscera the stomach seems to be frequently involved in the intermediate form, and the colon and stomach, sometimes accompanied by the small intestine, in the remote form. In the intermediate variety the stomach has been found wounded as it lay within the pleura and its contents extravasated. In the remote form it may have a very distinct hour-glass shape, the neck corresponding to the rent in the diaphragm.

In some cases the hernia is spontaneously reduced to be again protruded.

SYMPTOMS.—These are often obscure and puzzling. In the intermediate form all that usually attracts attention is rapidity of the pulse and respiration rate, the reason for which cannot be determined.

In the remote form the symptoms consist of abdominal

pain combined with a disturbance of the gastric or intestinal function. Sudden exacerbation of symptoms followed by an amelioration points to an involvement and release of the viscera.

When the stomach is involved, disturbances connected with the ingestion of food are the most marked, and when the large bowel is prolapsed obstruction is the predominant feature.

Gastric Form.—In the gastric form there is pain on taking food, sometimes trifling, sometimes severe. There may be difficulty in swallowing, which difficulty can be overcome by position, such as a dorsal or left-sided posture. Vomiting is frequent ; it may be spontaneous or purposely induced to give relief. If the hernia has been of long standing there may be great emaciation.

Colic Form.—Here there is usually a history of attacks of abdominal pain and constipation, with intervals of complete freedom from both. The intervals between the attacks are very various and often, in the early stage, amount to months. Later on the intervals become shorter. The patient is usually in good health and well nourished. The pain is the same as that met with in chronic obstruction, but is sometimes experienced in the left chest as well as in the abdomen. Sometimes the obstruction becomes acute.

Physical Signs.—If acute intestinal obstruction is not present the abdomen is nearly always normal. Even if the symptoms have suggested a hernia it is possible that the physical signs may be quite unconvincing. Whether the examination is helpful or not depends upon whether the hernia is large enough to displace or compress lung, or whether it contains air or fluid and so gives rise to abnormal noises. As a rule it is the stomach that produces the most pronounced physical sounds, both from its bulk and its air and fluid contents. The colon, if the obstruction is at the distal point of the involved bowel, will cause very much the same signs as the stomach.

The actual physical signs noted are as follows :—

(1) Dulness and absence of breath sounds.

(2) Feeble respiratory murmur and increased resonance.

(3) Tinkling, gurgling, or splashing sounds. These occur with the colon, but are more usually found with the stomach, where

ingestion of fluid may produce or increase them. There has been a difficulty in telling whether these signs originate in the abdomen or thorax. When heard they have not been appreciated at their proper value.

The diagnoses actually made have embraced the following : massive collapse of lung, subdiaphragmatic abscess containing air, and pneumothorax and hæmothorax.

X-ray Examination.—This has shown an absence of the usual lung shadow and an alteration in the position, form, and motility of the diaphragmatic vault. If the stomach is the organ involved a bismuth meal quickly makes the diagnosis, provided that it is herniated at the moment.

TREATMENT.—This is operative. If the diagnosis has been made, and there are no acute symptoms, the transpleural route is the best, and should be used in the first instance, though difficulties of reduction may necessitate a cœliotomy. When, however, the diagnosis is doubtful (and up till now it has seldom been made), the abdomen should be opened and the actual condition of things ascertained.

A paramedian incision is best. There may be an absence or a perfectly obvious displacement of stomach, colon, and omentum. On the other hand, all may appear normal. A manual examination of the diaphragmatic vault will quickly show the presence and site of the hernia, provided the contents are not reduced.

One must be on one's guard not to miss a small colic hernia. Such a hernia produces no obvious displacement of the viscera. and may be missed unless the continuity of the transverse and descending colon be carefully traced. The approximation at the hernial opening of the proximal and distal ends of the herniated loop may lead to the belief that the bowel is continuous within the abdomen, and that the only abnormality is a highly placed splenic flexure. If there are but few adhesions reduction may be effected from the abdomen, but if there are many it will be necessary to do this by the transpleural route. A finger introduced through the rent will indicate the best position in which to perform thoracotomy. Cowell's method is to be recommended.

Even after an abdominal reduction of the hernia contents a thoracotomy may be necessary to close a rent which is not suturable from beneath the diaphragm.

Obscure abdominal symptoms in a man previously shot through the lower chest should suggest the possibility of a diaphragmatic hernia. If this possibility is borne in mind a diagnosis will almost always be made, although the physical signs are puzzling. With the greater attention now paid to wounds of the diaphragm, the number will decrease, but some are still likely to occur and offer difficulties in diagnosis.

CHAPTER IX.

Causes of Failure.

COMPLICATING INJURIES.—One need say very little on this subject, except that every kind of bodily injury may be added to that of the abdomen. Compound depressed fractures of the skull, fractured long bones, multiple wounds, fractured spine, and avulsed limbs, are among such complicating injuries. In considering the total mortality, and in appraising the worth of abdominal surgery, one must take these injuries into account ; but for such extraneous injuries the mortality would be considerably lower.

MENTAL AND PHYSICAL STRAIN.—It is commonly said that the surgeon in war has an advantage over his peace colleague in that his subjects are healthy young adults. This, of course, is true ; but there is the strain caused by days of watching and alertness, and nights when sleep is difficult, interrupted, or impossible to obtain. Then there is the exertion of battle, which, for the time being at any rate, obliterates all sense of fatigue, so that many men do not know how tired they are until some wound is received which prevents them going farther. Next, there is the journey to the Casualty Clearing Station. Sometimes the men arrive practically asleep, and resent any interference or examination. Other men arrive in whom a state of excitement is still present, and they are willing and anxious to chatter about their experiences. Then, after being fed, they are dressed, and if they do not fall asleep in the process they do so immediately afterwards ; and it is one of the most striking sights of the medical side of war to see a large room filled with men lying on stretchers, some slightly wounded, some severely, some mortally, but all asleep, and asking for nothing but sleep. It is on such patients that the surgeon has to work, and it may well be imagined how much the mental and physical strain may increase the effect of injury.

W.S.A.   9

HÆMORRHAGE.—Hæmorrhage stands out as a great enemy of the surgeon. It comes from all sorts of places.

(1) *Stomach.*—Injury to the actual wall of the stomach apparently does not cause much hæmorrhage ; but damage to the vessels running on the stomach wall before they penetrate it, and to the big vessels lying on the two curvatures, does give rise to very great hæmorrhage.

(2) *Omentum.*—There may be a fair amount of hæmorrhage from this structure.

(3) *Small-intestine Wall.*—This is a source of considerable hæmorrhage, and in this way is perhaps a contrast to the stomach wall. It is not very unusual to see coils of the intestine filled with blood in addition to that which has escaped into the peritoneum.

(4) *Mesentery.*—The mesenteric vessels give rise to very considerable hæmorrhage. A mesentery wound often includes also a wound of the big vessels, such as the colics, and it is most probable that hæmorrhage from these vessels is the most common source of blood in the abdomen when the cases come to operation. The vessels in the mesentery are unsupported by masses of muscle, as are the vessels in the limbs, and for this reason one of the natural processes of hæmostasis is wanting. namely the pressure produced by the effused blood.

(5) *Retroperitoneal Tissue.*—Here hæmorrhage is a source of great trouble ; it often raises the posterior abdominal peritoneum so as to touch the anterior wall when the abdomen is open. It may look like a large purple intra-abdominal tumour. This surface shows cracks, through which the blood oozes slowly. If left, it may become infected and the seat of gas production. If, on the other hand, any attempt is made to find the bleeding point, the difficulty may be very great, even if the surgeon is successful. Whether this attempt is made must depend on the situation of the hæmatoma and the likelihood of injury to the big vessels. Most probably the best thing is to leave it alone, and to drain it through the loin if sepsis intervenes. There is often considerable shock, out of proportion, I should say, to the amount of blood lost. The sources of bleeding are the local

vessels, and sometimes the renal vessels or pelvic veins, or even the abdominal cava.

(6) *Abdominal Wall.*—In these cases the deep epigastric artery is the usual source of the trouble ; and in one case the whole abdomen was filled from a wound of this artery.

(7) *Great Vessels.*—The big vessels injured are the vena cava and the iliac veins, in addition to the renal and splenic veins. The abdominal cava has been closed by sutures by Captain Sampson, but the patient died. On another occasion the rent was successfully brought together by forceps by Captain Taylor ; the forceps were left on for the time being, and the patient was sent to the Base after their removal. The iliac arteries have been wounded and secured. So far no wound of the abdominal aorta has been dealt with at operation, but one was found at a *post-mortem.*

(8) *Solid Organs.*—The parenchyma of all solid organs bleeds freely at first ; but it is probable that if no large vessel is injured, the hæmorrhage will cease spontaneously in a few hours (four to eight). In one case, however, the splenic pulp was still found bleeding after twenty-four hours.

Within limits it is not so much the amount of blood lost that causes collapse as the suddenness of the loss.

Again, it is difficult to detect any definite relation between the amount of blood loss and the effect produced. A man can without detriment lose by the surgical operation of transfusion an amount of blood the loss of which would produce a decidedly bad effect on a wounded soldier.

SEPTIC ABSORPTION.—This takes place in four ways : (1) from the peritoneum, (2) from the retroperitoneal tissue, (3) from the wound itself, and (4) from the operation wound.

(1) *Peritonitis.*—There is nothing peculiar about the peritonitis compared with that seen in civil practice.

Peritonitis is the usual cause of death after the period of shock and hæmorrhage is over ; death may occur within twenty-four hours, or be delayed for a week or ten days. The first variety may be called the fulminating type, the second the dormant. It was the latter class which was seen so often at the

beginning of the war. These cases might or might not show signs of peritoneum involvement when first seen. If there were such signs, with rest in bed they would improve for a day or two and give the impression that things were quieting down. There might have been some vomiting, but this often subsided, and the tongue kept clean. Then the abdomen became tumid. But the general condition remained fair, and the pulse, if somewhat rapid, was not of bad quality. In some cases the patients then became obviously worse and died. In others the patients remained moderately well, or even appeared to have improved, and were sent to the Base, with the belief that they would recover. In some cases the journey to the Base seemed to light up the septic process, and they died soon after arrival. Others struggled on for some time further. One case may be mentioned in this connection : A man was shot in the abdomen, kept at a Casualty Clearing Station for eight days, and then evacuated, apparently doing well. On arrival at the Base he was ill, and was found to have a large iliac abscess, which was incised. He died on the following day. A *post-mortem* showed that into the fæcal abscess there opened two moderate-sized holes in the small intestine. It is a remarkable fact that in this case the bowels had acted normally on several occasions.

The amount of peritonitis present when operation is done at an early stage is very various, and within certain limits—to judge by the naked-eye appearances, which are known to be deceptive—it is not so dependent on the time elapsed since the wound as might be supposed. It has been found present in a marked degree in the case of a wound of the upper ileum after three hours and a half, and has been practically absent in the case of wounds of the jejunum after twenty-six hours. It is not altogether commensurate with the amount of fæcal escape. As regards prognosis, distension of the intestine is a better guide than the amount of visible inflammation. If the pulse is good when the abdomen is closed, the prognosis is good.

Peritonitis is, of course, brought about in some instances by contamination from the bowel ; but one must remember that

the projectile carries in dirt, even if it does not carry any cloth-
ing, and may in this way cause peritonitis apart from any
bowel injury. The fatal micro-organism is the streptococcus.
The anaerobes do not seem to be able to flourish in the abdominal
cavity. In this way the peritoneum resembles the synovial sacs
of joints.

The removal of the projectile is, of course, to be desired, but
it is almost impossible to find it in the posterior abdominal
wall, and the search for it may result in a great expenditure
of time.

The dissemination of infection is more a vital than a physical
process, though of course septic fluid and stomach contents
do gravitate to the pelvis. Bleeding of the mesentery, when in
conjunction with a wound of the bowel, must have a definite
influence in the spreading of infection. In two cases, Captain
Sampson had the blood in the abdomen examined, and this was
full of streptococci.

(2) *Retroperitoneal Sepsis.*—A series of *post-mortem* examina-
tions after abdominal injuries (made by Captain McNee and
Captain J. S. Dunn) has demonstrated the frequency of gas
gangrene and retroperitoneal sepsis in cases supposedly dead of
peritonitis or shock. It seems to be proved that this cause of
death is much more common than one supposed. The condition
may occur in two forms : (1) gaseous or (2) non-gaseous. It
may occur with or without a bowel lesion, but more usually
with one. The colon is generally the portion of the bowel impli-
cated, but it may follow wounds·of the duodenum. The infec-
tion is often one of extreme virulence, so that a man on admis-
sion is dying, and this even with an open wound. In other
cases it may follow a small innocent-looking wound in the
flank. When, on account of symptoms, such a wound is
explored, the retroperitoneal tissue may be black and stinking
or full of gas. At other times an incision shows only some blood-
stained areolar tissue without smell. A simple incision may be
all that is necessary, and the symptoms subside without any
signs of violent infection. At other times the discharge becomes
foul and evil-smelling, and the patient may succumb. Again, a
loin wound may go on well for a time; then the patient may

show signs of absorption, develop a fæcal fistula, and recover. At another time the skin of the loin becomes bronzed and crepitant, and the man dies rapidly in spite of incision. Bronzing of the skin is a curious manifestation, and its causation is not altogether obvious. In certain cases it subsides without any ill effects even if left alone ; but it is so often accompanied by " gas infection " that it is well to incise it at the earliest possible moment.

It is this sepsis which causes the high mortality in cases where a colon anus has been found necessary. Here the bowel has been widely wounded by the projectile, and the retroperitoneal tissue and muscles have been badly damaged. It seems impossible to stop such infection ; by the time the case comes under treatment it has got too far ahead, even though the patient at the time does not seem gravely ill. Even widely open drainage may be impotent.

A rather striking manifestation of the gaseous variety is seen when a retroperitoneal hæmatoma becomes infected. This may be palpable from the abdomen as a well-defined tumour, but resonant on percussion. Exploration reveals the cause—a gaseous hæmatoma.

(3) *Sepsis from the Projectile Wound.*—The wound caused by the missile may at any time show signs of sepsis and gas gangrene. In fact, it behaves just like the wounds of muscle in other parts of the body, and must be dealt with in the same way. It has caused death in a certain number of cases in which the intestinal lesion has been successfully dealt with. It used to be said that gas gangrene was not common in the trunk ; experience has shown that this immunity has been much overstated.

(4) *Sepsis from the Operation Wound.*—This, too, becomes badly infected in many cases. The cause may be a faulty technique, but I think it is nearly always due to infection from the abdomen. This is not to be wondered at, when nearly all abdominal wounds are accompanied by blood effusion, which is itself grossly infective. Very often the operation wound is the seat of intense infection, although the intestinal lesion does well. This is comparable with what is seen in the behaviour of the

operation wound and peritoneum respectively in cases of acute appendicitis.

RELATION BETWEEN THE AMOUNT OF INJURY AND THE AMOUNT OF COLLAPSE.—Something may be learnt from studying a man's sensations when hit. They vary in a remarkable degree.

Avulsion of portions of the abdominal wall may cause but little disturbance ; on the other hand, it more usually produces great shock, which may be suddenly fatal, either at once or after a short interval of time. As an example of a slight effect the following may be quoted : A man had his abdomen ripped open by a bullet just as we were compelled to evacuate a trench. He was bandaged up with a field dressing, and insisted on walking to a trench in the rear, where he lay on the fire step till things had quietened down. He was then evacuated, and made a good recovery. The following shows the opposite effect : A party of men were marching along a road just outside an advanced operating centre when an aerial bomb exploded in their midst. Twenty-two were brought in dead within a few minutes. Twelve had abdominal wounds, and of these the intestines were exposed in ten instances.

Sometimes a man is unconscious that his intestine is prolapsed. A soldier was hit just above the pubes ; he experienced very little inconvenience. When the first dressing was applied some of the small gut lay on the abdominal wall. He was taken to hospital, where he arrived in good condition and free from pain. Six to seven feet of the small gut lay outside the abdomen and perforated in several places. He made a good recovery.

Sometimes a man hit in the abdomen will believe that the injury is in the leg, a nerve having been injured and giving rise to reflected pain.

Another man, who subsequently died of peritonitis from a perforated ileum, when seen six hours after the injury was in good condition, free from pain, cheerful, and smoking a cigarette.

As a rule a man hit in the abdomen does, however, suffer pain, often intense, which dates from the moment of infliction.

The suddenness of the pain recalls that experienced in gastric perforation; it may be accompanied by collapse, transient or persistent.

Blows from large objects, such as shell caps, produce the same sensation as does any violent blow, such as a kick from the heels of a horse.

Small missiles may either cause a sharp stab or the feeling as if a tremendous blow had been administered. This sensation is also experienced in wounds of other parts of the body, and it is interesting to remember that it is also felt by those that rupture muscles while playing games.

The actual comparison of the amount of injury and the amount of disturbance is a very difficult subject. There are many obstacles in the way of accurately gauging the bearing that trauma has on collapse. Regimental officers who see the cases early can form no judgment—beyond gross lesions—as to the amount of intraperitoneal damage, and by the time the cases reach hospital it is impossible to exclude other factors in most cases.

Exposure or prolapse of the upper hollow viscera causes collapse, and so does avulsion of large portions of the abdominal wall.

Multiple lesions of hollow viscera produce a high mortality, but multiple lesions mean a long operation and are usually accompanied by much bleeding. It seems that multiple lesions are not great producers of collapse provided hæmorrhage and sepsis are absent. Recovery has followed as many as twenty lesions.

Shattering wounds of spleen and kidney cannot be said to be alarming injuries in themselves. Extensive wounds of the liver are. Where both kidneys are involved death follows, but this cannot be attributed to collapse.

Finally, three cases may be quoted to show that abdominal injuries may at one time completely incapacitate a man and at another do not at once prevent the individual from continuing his work :—

(1) An ambulance driver was hit in the abdomen by a shell fragment. He experienced severe pain, became collapsed,

broke out into a profuse sweat, and vomited. He continued collapsed until the operation, which revealed perforative lesions in the small gut and a considerable amount of blood in the belly. He recovered.

(2) A bearer in the Royal Army Medical Corps wounded in the intestine, as a subsequent operation proved, was brought to an Advanced Dressing Station on a stretcher. As there were many wounded to be attended to, he got up and gave a hand.

(3) An airman was hit by a shell fragment far behind the German lines. He brought his machine safely back and made a good landing. He reached a hospital in good condition. Two holes in the small gut were sewn up. He died of acute sepsis of the retroperitoneal tissue after forty-eight hours.

Clinical Shock.

All the above-mentioned factors, namely mental and physical strain, want of sleep, exposure to cold and wet, hunger, thirst, horror, disturbance, sepsis, hæmorrhage, and possibly in addition " pure shock," acting singly or together in varying proportions, cause shock as seen by the clinical surgeon. They are operative both before and after operation, so that no distinction need be drawn.

Clinical shock * is usually characterised by a rapid, weak, and sometimes imperceptible pulse, a low blood pressure, a depressed body temperature.

As may be gathered from what has been said on a man's sensations on being hit, shock commences in two ways. It may come on soon after the receipt of the wound, the patient suddenly collapsing, breaking out into a cold sweat, and vomiting. This condition may pass off altogether, or pass off and again become established, or may persist and deepen. In other cases it is absent at first, but gradually develops, especially if the patient is not artificially warmed.

A shocked man has a lowering of his blood alkalinity, and

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* See report on shock to the Medical Research Committee by Messrs. Cannon, Fraser, and Cowell.

this fall in alkalinity is accompanied by a fall in blood pressure. What the actual relation between the two may be has not yet been established.   This loss of alkalinity is increased by operation and the administration of an anæsthetic.

There are then three conditions to be combated in the shocked man : a low body temperature, a low blood pressure, and a low blood alkalinity.

A Low Body Temperature.—The low temperature is due to a decreased production of heat.   A shocked man is almost like a cold-blooded animal and tends to take the temperature of his surroundings.   The chill that a man feels when he suddenly breaks out into a cold sweat is due to a constriction of surface vessels, but this subjective sensation of cold is soon replaced by an actual fall in the body heat.   The men wounded in the bomb attack mentioned above were admitted into hospital so quickly that they were actually warm when put to bed, but got cold there before the artificial heat had time to act.

Observations have shown that if a man is adequately warmed shock may be averted in many instances.   The first place where this can be properly done is the Regimental Aid-Post.   It sometimes takes an hour and a half to reach this, even if evacuation is possible.   It is important, therefore, that blankets should be attached to all stretchers.   Morphia should be given as soon after injury as possible.   All Regimental Aid-Posts should, if possible, be well warmed, and arrangements made for heating the wounded man by placing him on a stretcher, which is converted into a warm bed as follows.   The stretcher is placed on trestles.   The blankets covering the stretcher are allowed to hang down over the sides.   The space beneath the stretcher is then converted into a hot air chamber by placing a lamp in it.   The man is laid on a folded blanket, and the patient when sent on his journey is covered, in addition, by the portions of the two blankets that have so far hung down.   He has thus four thicknesses of blanket above and below him.   At the Regimental Aid-Post wet clothes are removed provided the atmosphere is warm and there are substitutes.   Hot fluids and a drachm of bicarbonate of soda are also to be administered.

When   the   patient   arrives   at   the   Advanced   Dressing

Station he is again placed on a warmed stretcher and fluids administered.

When the hospital is reached the man may be undressed and put to bed if not in bad state. If in bad state he should again be placed on a warmed stretcher, and when sufficiently recovered undressed while still on the stretcher and then placed in bed and the heating continued by means of the electric or hot air cradle. Alkali should again be given by the mouth, if possible, if there is no vomiting.

Warmth is the most potent restorative we have.

A Low Blood Pressure and Loss of Blood Alkalinity.—The weak and rapid pulse and low blood pressure are due (in some cases, at all events) to a loss of blood volume.

This loss of blood volume may be caused by a direct hæmorrhage, by stagnation of blood in certain vessels, or by the blood fluids passing through the vessel walls into the body tissues.

As to stagnation of the blood in certain areas, it can be said that there is no clinical evidence that it is stored up in the abdominal viscera.

A discrepancy that has been noticed between the cutaneous capillary and venous count may be caused by an extra-vascular accumulation of blood fluids in the skin area. The pressure may be raised by rest and quiet and by fluids administered by the mouth or rectum. If no result occurs, the question of infusion or transfusion will arise. It is somewhat doubtful if either is worth doing if the patient shows no signs of rallying after treatment by warmth and rest unless the patient is obviously suffering from loss of blood.

Isotonic and hypertonic solutions are well nigh useless as means of raising and sustaining the pressure, though they are of use in increasing the blood alkalinity if bicarbonate of soda is used instead of sodium chloride.

The choice therefore seems to be between blood transfusion and Bayliss' 6 per cent. gum in a 2 per cent. sodium bicarbonate solution.

If a man has bled much transfusion is by far the best, but Bayliss' solution is a good substitute if a donor is not available or if the case is not thought sufficiently grave.

A question arises as to whether injection of fluids into the veins should be done before an operation centre is reached. In deciding this point it may be doubted if it is wise to raise the blood pressure before the source of the bleeding can be checked by operation.

CHAPTER X.

Statistics, Results, and the Future.

Mortality in the Preoperative Days.

The expectant treatment of abdominal injuries was the method of choice in the armies of all the combatants at the beginning of the war. Gradually, on every side, the operative has replaced the older method.

Although it is very difficult to compare the results of the two methods, expectant and operative, some interest attaches to the figures obtained in the two periods respectively. The figures in the preoperative periods had to be taken from the admission and discharge books of the Field Ambulances and Casualty Clearing Stations, as no separate books were kept; consequently the figures could only be computed. In the second period special books were used, and the figures may be taken as approximately correct.

Into nine Field Ambulances over a period of six months there were admitted 1,098 abdominal wounds, with 333 deaths—a mortality of 30 per cent. In the six Casualty Clearing Stations during the same period there were admitted 131 cases of perforating abdominal wounds, with 73 deaths. From these figures it appears that the total mortality in the Field Ambulances and Clearing Stations was about 70 per cent.

There were also the deaths at the Base in France to be added, and in the preoperative days to which we now allude many such deaths occurred, which would, as far as can be judged, bring the mortality up to about 80 per cent. Makins gives the death-rate at the Base among small-gut wounds as 84 per cent., and among colon wounds as 46·4 per cent. in this period.

The period covered by these figures was the first six months of 1915.

Method of recording Cases.

The figures quoted in this book (unless stated otherwise) are based on all the abdominal wounds which reached an operating hospital from a certain sector of the line over a period of eighteen months (July 1st, 1915, to December 31st, 1916). The beginning of this period coincided with the commencement of the operative treatment.

In forming an estimate of the mortality of abdominal wounds, and what can be done for them by operative treatment, it is necessary to include all the cases, no matter at what hospital they are treated. Results differ in different hospitals, more or less depending upon their distance from the firing line ; they will also differ according to the nature of the fighting; they are nearly always worse at the end of a fight than at the beginning, for the cases admitted at the end have often been difficult to collect and are therefore late in arriving. Again, if times are quiet, there is plenty of time to treat all cases adequately and deliberately ; at another time, when active operations are in progress, it may be only possible to pay attention to the most favourable cases. It is therefore necessary not only to reckon the operative mortality, but also to bring into account all cases which die without operation. This has been done in the present series. In the case of the moribund, we have their numbers, but we do not in every case possess details of the injury.

The statistics were collected in the following way : Every hospital which was called upon to treat abdominal cases was provided with a book, in which certain headings were written down, and these were filled in at the time of operation by the medical officers. These books were provided by the Medical Research Committee.

Comparative Mortality at Different Hospitals.

Table XXXI. shows the variations in results which may be obtained in different hospitals.

TABLE XXXI.—*Variations in the Results obtained in Different Hospitals.*

Unit.	Mortality.	
	Total.	Operative.
(1) A Casualty Clearing Station	54	45
(2) ,, ,, ,, ...	72·7	—
(3) An abdominal hospital	36·4	—
(4) ,, ,, ,, ...	82·6	48·8
(5) A Casualty Clearing Station	50	44·4
(6) An abdominal hospital	56·4	52·6

Note.—(1), (2), (3), (4) During same battle.   (5) Same as (1) but in a quiet time.   (6) Same as (3) in a quiet time over a six-months period.

TABLE XXXI.A.—*Results obtained in* 1917 (*Fighting and Quiet Times*) *in Sectors that were adjacent.*

Unit.	Mortality.	
	Total.	Operative.
A Casualty Clearing Station	44·3	39·6
,, ,, ,, ...	68·3	62·4
An advanced operating centre	65	56·9

TABLE XXXI.B.—*Some other Results from other Portions of the Line in* 1916 *during Fighting.*

Unit.	Mortality.	
	Total.	Operative.
(1) An advanced operating centre	64·3	58·5
(2) A Casualty Clearing Station	65·8	51·9
(3) An advanced operating centre	—	51
(4) A Casualty Clearing Station	76·5	80·9

(4) Was situated behind (3) and only took in cases when (3) was full, usually towards the end of a fight.

Results of Operative Treatment.

The period during which detailed statistics are available covers the time between July 1st, 1915, and December 31st, 1916.

The results of the operative treatment have also been compiled up to September 30th, 1917.

TABLE XXXI.c.—*To show Results in Successive Periods.*

	July 1st, 1915, to Dec. 31st, 1915.	July 1st, 1915, to Dec. 31st, 1916.	July 1st, 1915, to Sept. 30th, 1917.	Jan. 1st, 1917, to Sept. 30th, 1917.
Total cases	511	1,288	2,127	839
Moribund cases	145	250	420	170
Total mortality, excluding moribund	45·8	50·06	50·02	49
Total mortality, including moribund	61·25	60·2	59·9	59·5
Considered with view to operation	366	1,038	1,707	669
Operation not thought necessary	56	73	102	29
Total operations	310	965	1,605	640
Total operative mortality . .	53·9	53·9	52·9	51·3
Hollow viscera ,, . .	64·5	64·7	—	—
Stomach* ,, . .	43·75	52·7	—	—
Small gut* ,, . .	63·8	65·9	—	—
Colon* ,, . .	60	58·7	—	—

* Uncomplicated by any other lesion of the alimentary canal.

The above table shows the results obtained over extending periods of time, starting from the commencement of the operative treatment. The first and latest periods can be compared in first and last columns.

The uniformity of the figures is rather remarkable.

TABLE XXXII.—*Short Table of Operations, showing also the Number of Operated and Non-operated Cases, July 1st, 1915, to December 31st, 1916.*

Operations.	To Base.	Died.
(1) Suture of stomach	26	29
(2) ,, ,, and other operations on the intestinal tube	6	21
(3) Resection of small gut	26	89
(4) ,, ,, ., and other operations on the intestinal tube not included in (2). .	5	34

TABLE XXXII.—*Continued.*

Operations.	To Base.	Died.
(5) Suture of small gut	59	71
(6) ,, ,, ,, and other operations on the intestinal tube not included in (2) ..	17	33
(7) Formation of small-gut anus	—	7
(8) For small-gut fistula	2	1
(9) Suture of colon	50	52
(10) Formation of colon anus	13	36
(11) For wounded rectum (proximal colostomy not included)	3	5
(12) Proximal colostomy	4	10
(13) Cœliotomy, no hollow viscus perforated ..	89	33
(14) ,, liver wounded	76	38
(15) Kidney, exploration of	25	7
(16) ,, excision of	6	7
(17) For wounded bladder	11	14
(18) Spleen, exploration of	12	4
(19) ,, excision of	4	12
(20) Miscellaneous operations	10	18
(21) No operation advised	69	4
(22) ,, moribund	—	250
Totals	513	775
Grand total	1,288	

TABLE XXXIII.—*Details of Operations, etc., shown in Table* XXXII.

Operations.	To Base.	Died.	Total.
Suture of stomach	26	29	55
,, ,, and small gut	4	6	10
Suture of stomach and small gut ; gastro-jejunostomy	—	2	2
Suture of stomach and great gut	2	3	5
,, ,, ,, colon ; gastro-jejunostomy	—	1	1
,, ,, small gut, and colon ..	—	3	3
Suture of stomach ; resection of small gut ; gastro-jejunostomy	—	2	2
Suture of stomach and colon ; resection of small gut	—	1	1

TABLE **XXXIII.**—*Continued.*

Operations.	To Base.	Died.	Total.
Suture of stomach ; resection of small gut ; gastro-jejunostomy ; colon anus	—	1	1
Suture of stomach ; colon anus	—	2	2
Resection of small gut ; circular enterorrhaphy	18	69	87
,, ,, lateral anastomosis ..	8	18	26
,, ,, gastro-jejunostomy ..	—	2	2
,, ,, suture of colon ..	4	17	21
,, ,, colon anus	1	14	15
,, ,, suture of rectum ..	—	3	3
Suture of small gut	59	71	130
,, ,, and colon..	16	26	42
Suture of small gut ; resection of colon ..	—	1	1
,, ,, colon anus	1	5	6
Suture of small gut and rectum	—	1	1
Small-gut anus	—	7	7
,, fistula	2	1	3
Suture of colon—			
Cæcum	8	5	13
Ascending colon	13	12	25
Hepatic flexure	7	9	16
Transverse colon	5	8	13
Splenic flexure	4	6	10
Descending colon	6	3	9
Pelvic colon	7	9	16
Colon anus	13	36	49
On rectum, intraperitoneal wounds ..	1	2	3
,, extraperitoneal ,, ..	2	3	5
Proximal colostomy	4	10	14
Cœliotomy, no hollow viscus perforated ..	77	30	107
,, non-penetrating wounds ..	12	3	15
On liver	76	38	114
On kidney : exploration	25	7	32
,, nephrectomy	6	7	13
For wounds of bladder—			
Extraperitoneal—			
Suprapubic	6	9	15
Drainage of wound	3	1	4
Suture	—	1	1
Intraperitoneal—			
Suprapubic	—	1	1
Suture	2	2	4
For wounds of spleen : exploration	12	4	16
,, ,, splenectomy ..	4	12	16
For fæcal abscess	1	6	7
For loss of belly wall	—	1	1
For prolapse of viscera..	6	3	9

Table **XXXIII.**—*Continued.*

Operations.					To Base.	Died.	Total.
Tube to pelvis ..	..	..	..	..	—	4	4
For contusion of belly ..	..	..	..		—	2	2
Loin wound enlarged ..	..	..	..		3	2	5
No operation (no indication) ..	..	..	..		69	4	73
,, moribund	..	..	..		—	250	250

Note.—This table shows the number of individuals operated upon. In the case of the intestinal tract it shows the number of times the different parts were hit. The bladder and solid organs only appear in the table when they were the principal viscera damaged.

The Future.

There can be no doubt that the success obtained has been due to several factors. These are mainly—

(1) The magnificent way in which the wounded are collected by the bearers, both regimental and those belonging to the Field Ambulances. Honestly, one cannot sufficiently express one's admiration for their courage, steadfastness, and endurance.

(2) The motor ambulances of the Field Ambulances and of the motor convoys. What praise is not due to the drivers who in darkness and shell-fire tenderly pick their way among the holes in the road so as to avoid a needless jolt to their wounded charges ?

(3) The fixity of the fighting line, which has allowed the Clearing Station to develop to its present condition.

(4) The wisdom of those that administer the Royal Army Medical Corps in that they have abandoned the old tradition that operations cannot be performed near a fighting area.

Can the past results be maintained if the fighting becomes open and the armies get on the move ? Motor ambulances can diminish distance, but they cannot entirely obliterate it.

It all depends on whether the Casualty Clearing Stations can be moved sufficiently quickly.

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